

# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-317509

(43)Date of publication of application : 16.11.1999

(51)Int.Cl.

H01L 27/12  
H01L 21/02

(21)Application number : 11-039261

(71)Applicant : CANON INC

(22)Date of filing : 17.02.1999

(72)Inventor : OMI KAZUAKI

SAKAGUCHI KIYOBUMI

YANAGIDA KAZUTAKA

(30)Priority

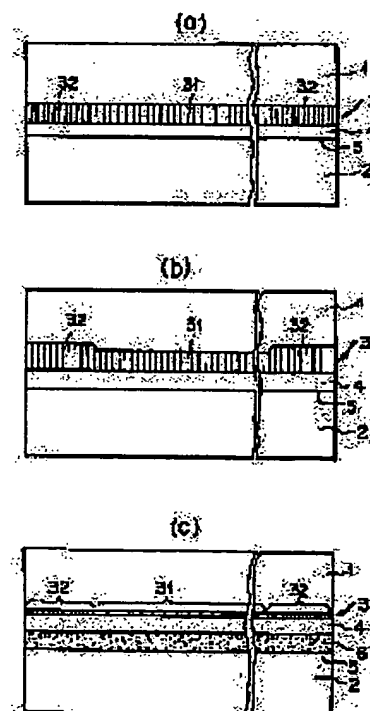
Priority number : 10 35820 Priority date : 18.02.1998 Priority country : JP

(54) COMPOUND MEMBER, ITS SEPARATING METHOD AND MANUFACTURING METHOD OF SEMICONDUCTOR SUBSTRATE USING THE METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To realize a compound member capable of being separated relatively easily, without damaging the separated substrate as well as the separating method of the compound member.

SOLUTION: In the separating method of a compound member, including the separating step of the compound member into multiple members in a separating region 3, the mechanical strength in the separating region 3 is made uneven in the direction along the laminating surface 5 to be attained by the manufacturing method of a semiconductor substrate. In particular, it is preferable that the mechanical strength in the peripheral part of the compound member in the separating region 3 be less than that in the central part. In addition, it is also preferable that the mechanical strength the separating region 3 be also less than that in the laminated location.



## LEGAL STATUS

[Date of request for examination]

22.06.1999

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application]

BEST AVAILABLE COPY

converted registration]

[Date of final disposal for application]

[Patent number]

3031904

[Date of registration]

10.02.2000

[Number of appeal against examiner's decision of  
rejection]

[Date of requesting appeal against examiner's  
decision of rejection]

[Date of extinction of right]

Copyright (C); 1998,2003 Japan Patent Office

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開平11-317509

(43) 公開日 平成11年(1999)11月16日

(51) Int. Cl.<sup>6</sup>

H 0 1 L 27/12  
21/02

識別記号

P I

H 0 1 L 27/12  
21/02

B  
B

審査請求 有 請求項の数 9 O L (全 22 頁)

(21) 出願番号 特願平11-39261

(22) 出願日 平成11年(1999) 2月17日

(31) 優先権主張番号 特願平10-35820

(32) 優先日 平10(1998) 2月18日

(33) 優先権主張国 日本 (J P)

(71) 出願人 000001007

キヤノン株式会社

東京都大田区下丸子3丁目30番2号

(72) 発明者 近江 和明

東京都大田区下丸子3丁目30番2号 キヤ  
ノン株式会社内

(72) 発明者 坂口 清文

東京都大田区下丸子3丁目30番2号 キヤ  
ノン株式会社内

(72) 発明者 柳田 一隆

東京都大田区下丸子3丁目30番2号 キヤ  
ノン株式会社内

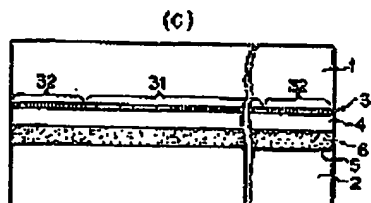
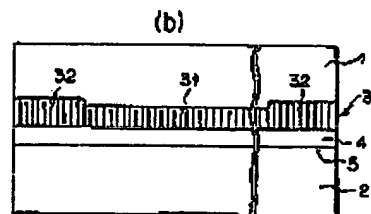
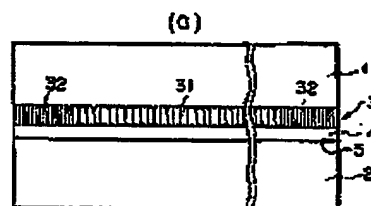
(74) 代理人 弁理士 山下 義平

(54) 【発明の名称】 複合部材とその分離方法、及びそれを利用した半導体基体の製造方法

(57) 【要約】

【課題】 分離した基体を破損することなく、複合部材を比較的容易に分離することができる複合部材とその分離方法を提供することにある。

【解決手段】 複合部材を分離領域で複数の部材に分離する工程を含む複合部材の分離方法において、分離領域の機械的強度が該貼り合わせ面に沿った方向に不均一であることを特徴とする。半導体基体の製造方法により達成できる。特に前記分離領域の内の複合部材周辺部の機械的強度が中央部よりも弱いことが好ましい。また同時に前記分離領域は機械的強度が前記貼り合わせ箇所よりも弱いことが好ましい。



## 【特許請求の範囲】

【請求項1】 複合部材を、分離領域で複数の部材に分離する工程を含む複合部材の分離方法において、前記分離領域の機械的強度が前記複合部材の表面に沿った方向に不均一であり該分離領域の周辺部の機械的強度が局所的に弱いことを特徴とする分離方法。

【請求項2】 前記分離領域の機械的強度が貼り合わせ箇所よりも弱い請求項1に記載の分離方法。

【請求項3】 前記分離領域が陽極化成法によって形成された多孔質層である請求項1に記載の分離方法。

【請求項4】 前記複合部材が微略円盤状であり、前記分離領域の機械的強度が該複合部材内の中央部で高く周辺部で低く、且つ円周方向に沿ってほぼ均一である請求項1に記載の分離方法。

【請求項5】 互いに多孔度の異なる部分を形成することによって前記分離領域の機械的強度を不均一にする請求項1に記載の分離方法。

【請求項6】 前記分離領域の多孔度を中央部よりも周辺部で高くする請求項1に記載の分離方法。

【請求項7】 前記分離領域に、互に厚さの異なる部分を形成することによって機械的強度を不均一にする請求項1に記載の分離方法。

【請求項8】 前記多孔質層の厚さを中央部よりも周辺部で厚くする請求項5に記載の分離方法。

【請求項9】 前記分離領域が機械的強度の異なる複数の層からなる請求項1に記載の分離方法。

【請求項10】 前記分離領域は多孔度が高い層と多孔度が低い層とを有する請求項1に記載の分離方法。

【請求項11】 前記多孔度が高い層の多孔度が中央部よりも周辺部でより高い請求項10に記載の分離方法。

【請求項12】 前記多孔度が低い層の厚さを中央部よりも周辺部で厚くし、前記多孔度が高い層の多孔度を中央部よりも周辺部で高くする請求項10に記載の分離方法。

【請求項13】 前記分離領域を形成するための陽極化成の電流密度を面内で変化させることにより前記多孔度が低い層の周辺部における厚さを基体の中央部より厚くすることを特徴とする請求項12に記載の分離方法。

【請求項14】 前記陽極化成される基体の近傍における陽極化成液中のイオン電流が流れる断面積を、前記基体の面積よりも大きくすることによって、周辺部に流入する化成電流の面密度を中央部に流入する化成電流の面密度よりも大きくし、これによりその後に形成する前記多孔度の高い層の周辺部の多孔度を中央部の多孔度より高くすることを特徴とする請求項13に記載の分離方法。

【請求項15】 前記陽極化成される基体近傍に、前記基体表面に流入するイオン電流分布を制御する電流ガイドを設けて、前記多孔度の低い層の厚さを面内で異なら

しめることを特徴とする請求項13に記載の分離方法。

【請求項16】 前記分離領域は、イオン打ち込みにより形成された微小気泡を得ることのできる層である請求項1に記載の分離方法。

【請求項17】 前記分離領域の周辺部のイオン注入量を中央部より大きくする請求項16に記載の分離方法。

【請求項18】 流体を吹き付けることにより、前記分離領域に亀裂を生じさせることを特徴とする請求項1に記載の分離方法。

10 【請求項19】 前記流体を吹き付ける方法として、高圧の水流をノズルから吹き出すウォーター・ジェット法を用いる請求項18に記載の分離方法。

【請求項20】 前記複合部材の側面に、流体を受けて分離領域を押し並げる方向の力を生ずるような、凹型を形成する請求項18に記載の分離方法。

【請求項21】 前記複合部材は単結晶シリコン基板を部分的に多孔質化することによって多孔質単結晶シリコン層を形成し、該多孔質単結晶シリコン層上に非多孔質単結晶シリコン層をエピタキシャル成長することによって形成された基体を有することを特徴とする請求項18に記載の分離方法。

【請求項22】 前記複合部材は第一の基体と第二の基体が、絶縁層を介して貼り合わされたものであり、該絶縁層は前記第一の基体の非多孔質単結晶シリコン層の表面を酸化することによって形成されたものであることを特徴とする請求項1に記載の分離方法。

【請求項23】 前記分離領域として単結晶半導体から成る第一の基体の所定の深さにイオンを打ち込むことにより、微小気泡層（microcavity 層）を得ることのできるイオン打ち込み層を形成する工程、前記第一の基体と第二の基体とを、前記第一の基体のイオンを打ち込んだ面が内側に位置する複合部材が得られるように、貼り合わせる工程、及び前記複合部材の側面に流体を吹き付けることにより、前記複合部材を分離する工程を有することを特徴とする請求項1に記載の分離方法。

【請求項24】 前記複合部材の側面に、流体を受けてイオン打ち込み層を押し並げる方向の力を生ずるような、凹型を持たせる請求項1に記載の分離方法。

【請求項25】 前記イオン打ち込み層は、前記貼り合わせ箇所よりも機械的強度が弱い請求項23に記載の分離方法。

【請求項26】 前記周辺部の多孔度と、多孔度の極小値と、の差が5%以上である請求項1に記載の分離方法。

【請求項27】 前記周辺部の多孔度と、多孔度の極小値と、の差が10%以上である請求項1に記載の分離方法。

【請求項28】 前記周辺部の多孔度は、20%以上80%以下から選択される請求項1に記載の分離方法。

【請求項29】 前記周辺部の多孔度は、35%以上

0%以下から選択される請求項1に記載の分離方法。

【請求項30】 前記中央部の多孔度は5%以上35%未満から選択される請求項1に記載の分離方法。

【請求項31】 前記中央部の多孔度は5%以上20%未満から選択される請求項1に記載の分離方法。

【請求項32】 前記分離領域は、前記周辺部の面積より機械的強度が高い部分の面積が大きい請求項1に記載の分離方法。

【請求項33】 前記分離領域は、機械的強度が高い部分が前記複合部材の中心からずれている請求項1に記載の分離方法。

【請求項34】 請求項1に記載の分離方法を用いた半導体基体の製造方法。

【請求項35】 第一の基体と第二の基体が互いに貼り合わされた複合部材を、貼り合わせ面とは異なる箇所に形成された分離領域で複数の部材に分離する工程を含む半導体基体の製造方法において、前記分離領域の機械的強度が該貼り合わせ面に沿った方向に不均一であり該分離領域の周辺部の機械的強度が局所的に弱いことを特徴とする半導体基体の製造方法。

【請求項36】 前記分離領域の機械的強度が前記貼り合わせ面よりも弱い請求項35に記載の半導体基体の製造方法。

【請求項37】 前記分離領域が陽極化成法によって形成された多孔質層である請求項35に記載の半導体基体の製造方法。

【請求項38】 前記複合部材が概略円盤状であり、前記分離領域の機械的強度が該複合部材内の中央部で高く周辺部で低く、且つ円周方向に沿ってほぼ均一である請求項35に記載の半導体基体の製造方法。

【請求項39】 互いに多孔度の異なる部分を形成することによって前記分離領域の機械的強度を不均一にする請求項35に記載の半導体基体の製造方法。

【請求項40】 前記分離領域の多孔度を中央部よりも周辺部で高くする請求項35に記載の半導体基体の製造方法。

【請求項41】 前記分離領域に、互に厚さの異なる部分を形成することによって機械的強度を不均一にする請求項35に記載の半導体基体の製造方法。

【請求項42】 前記多孔質層の厚さを中央部よりも周辺部で厚くする請求項38に記載の半導体基体の製造方法。

【請求項43】 前記分離領域が機械的強度の異なる複数の層からなる請求項35に記載の半導体基体の製造方法。

【請求項44】 前記分離領域は多孔度が高い層と多孔度が低い層とを有する請求項35に記載の半導体基体の製造方法。

【請求項45】 前記多孔度が高い層の多孔度が中央部よりも周辺部で高い請求項43に記載の半導体基体の

の製造方法。

【請求項46】 前記多孔度が低い層の厚さを中央部よりも周辺部で厚くし、前記多孔度が高い層の多孔度を中央部よりも周辺部で高くする請求項43に記載の半導体基体の製造方法。

【請求項47】 陽極化成の電流密度を面内で変化させることにより前記多孔度が低い層の周辺部における厚さを基体の中央部より厚くすることを特徴とする請求項46に記載の半導体基体の製造方法。

10 【請求項48】 陽極化成される前記第一の基体の近傍における陽極化成液中のイオン電流が流れる断面積を、前記第一の基体の面積よりも大きくすることによって、周辺部に流入する化成電流の面密度を中央部に流入する化成電流の面密度よりも大きくし、前記多孔度の低い層の周辺部の厚さを中央部より厚くし、これによりその後に形成する前記多孔度の高い層の周辺部の多孔度を中央部の多孔度より高くすることを特徴とする請求項47に記載の半導体基体の製造方法。

20 【請求項49】 前記陽極化成される第一の基体近傍に、前記第一の基体表面に流入するイオン電流分布を制御する電流ガイドを設けて、前記多孔度の低い層の厚さを面内で異ならしめることを特徴とする請求項47に記載の半導体基体の製造方法。

【請求項50】 前記分離領域は、イオン打ち込みにより形成された微小気泡を得ることのできる層である請求項35に記載の半導体基体の製造方法。

【請求項51】 周辺部のイオン注入量を中央部より大きくする請求項50に記載の半導体基体の製造方法。

30 【請求項52】 前記分離領域付近に流体を吹き付けることにより、前記分離領域に亀裂を生じさせることを特徴とする請求項35に記載の半導体基体の製造方法。

【請求項53】 前記流体を吹き付ける方法として、高圧の水流をノズルから吹き出すウォーター・ジェット法を用いる請求項52に記載の半導体基体の製造方法。

【請求項54】 前記複合部材の側面に、流体を受けて分離領域を押し広げる方向の力を生ずるような、凹型を持たせる請求項52に記載の半導体基体の製造方法。

【請求項55】 前記第一の基体は、単結晶シリコン基板を部分的に多孔質化することによって多孔質単結晶シリコン層を形成し、該多孔質単結晶シリコン層上に非多孔質単結晶シリコン層をエピタキシャル成長することによって形成される請求項35に記載の半導体基体の製造方法。

【請求項56】 前記第一の基体と前記第二の基体は、絶縁層を介して貼り合わされ、該絶縁層は前記第一の基体の非多孔質単結晶シリコン層の表面を酸化することによって形成される請求項54に記載の半導体基体の製造方法。

【請求項57】 前記分離領域として単結晶半導体からなる第一の基体の近傍の面にイオンを打ち込むこと

より、微小気泡層を得ることのできるイオン打ち込み層を形成する工程、前記第一の基体と第二の基体とを、前記第一の基体のイオンを打ち込んだ面が内側に位置する複合部材が得られるように、貼り合わせる工程、及び前記複合部材の側面に流体を吹き付けることにより、前記複合部材を分離する工程を有することを特徴とする請求項35に記載の半導体基体の製造方法。

【請求項58】 前記複合部材の側面に、流体を受けてイオン打ち込み層を押し並げる方向の力を生ずるような、凹型を持たせる請求項35に記載の半導体基体の製造方法。

【請求項59】 前記イオン打ち込み層は、前記貼り合わせ面よりも機械的強度が弱い請求項57に記載の半導体基体の製造方法。

【請求項60】 前記周辺部の多孔度と、多孔度の極小値と、の差が5%以上である請求項35に記載の半導体基体の製造方法。

【請求項61】 前記周辺部の多孔度と、多孔度の極小値と、の差が10%以上である請求項35に記載の半導体基体の製造方法。

【請求項62】 前記周辺部の多孔度は、20%以上80%以下から選択される請求項35に記載の半導体基体の製造方法。

【請求項63】 前記周辺部の多孔度は、35%以上80%以下から選択される請求項35に記載の半導体基体の製造方法。

【請求項64】 前記中央部の多孔度は5%以上35%未満から選択される請求項35に記載の半導体基体の製造方法。

【請求項65】 前記中央部の多孔度は5%以上20%未満から選択される請求項35に記載の半導体基体の製造方法。

【請求項66】 前記分離領域は、前記周辺部の面積より機械的強度が高い部分の面積が大きい請求項35に記載の半導体基体の製造方法。

【請求項67】 前記分離領域は、機械的強度が高い部分が前記複合部材の中心からずれている請求項35に記載の半導体基体の製造方法。

【請求項68】 内部に分離領域を有する複合部材において、前記分離領域の機械的強度が該複合部材の表面に沿った方向に不均一であり、該分離領域の周辺部の機械的強度が局所的に弱いことを特徴とする複合部材。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、複合部材とその分離方法並びに半導体基体の製造方法に関し、特に、内部に機械的強度が弱い脆弱構造部を有する複合部材とそれを分離する分離方法並びに半導体基体の製造方法に関する。本発明は、特に半導体基体の一種であるSOI (Semiconductor on insulator) 構造を有する基板 (SOI 基

基板) の製法に適している。

【0002】

【従来の技術】 このSOI 基板を採用したデバイスは、通常のS<sub>i</sub> 基板では達成し得ない数々の優位点を有する。この優位点としては、例えば、以下のものが挙げられる。

(1) 誘電体分離が容易で高集積化に適している。

(2) 放射線耐性に優れている。

(3) 浮遊容量が小さく、素子の動作速度の高速化が可能である。

(4) ウェル工程が不要である。

(5) ラッチアップを防止できる。

(6) 薄膜化による完全な空乏型電界効果トランジスタの形成が可能である。

【0003】 SOI 構造は、上記のような様々な優位点を有するため、ここ数十年、その形成方法に関する研究が進められてきた。

【0004】 SOI 技術としては、古くは、単結晶サファイア基板上にS<sub>i</sub> をCVD (化学気相成長) 法でヘテロエピタキシ成長させて形成するSOS (silicon on sapphire) 技術が知られている。このSOS技術は、最も成熟したSOI 技術として一応の評価を得たものの、S<sub>i</sub> 層と下地のサファイア基板との界面における格子不整合による大量の結晶欠陥の発生、サファイア基板を構成するアルミニウムのS<sub>i</sub> 層への浸入、基板の価格、大面積化への遅れ等の理由により実用化が進んでいない。

【0005】 SOS技術に次いで、SIMOX (separation by ion implanted oxygen) 技術が登場した。このSIMOX技術に関して、結晶欠陥の低減や製造コストの低減等を目指して様々な方法が試みられてきた。この方法としては、基板に酸素イオンを注入して埋め込み酸化層を形成する方法、酸化膜を挟んで2枚のウェハを貼り合わせて一方のウェハを研磨又はエッチングして、薄い単結晶S<sub>i</sub> 層を酸化膜上に残す方法、更には、酸化膜が形成されたS<sub>i</sub> 基板の表面から所定の深さに水素イオンを打ち込み、他方の基板と貼り合わせた後に、加熱処理等により該酸化膜上に薄い単結晶S<sub>i</sub> 層を残して、貼り合わせた基板 (他方の基板) を剥離する方法等が挙げられる。

【0006】 特許第2608351号公報や米国特許第5,371,037号において、新たなSOI 技術を開示した。この技術は、多孔質層が形成された単結晶半導体基板上に非多孔質単結晶層を形成した第一の基板を、第二の基板に貼り合わせ、その後、不要部分を除去することにより、第二の基板に非多孔質単結晶層を移設するものである。この技術は、SOI 層の膜厚均一性が優れていること、SOI 層の結晶欠陥密度を低減し得ること、SOI 層の表面平坦性が良好であること、高価な特殊仕様の製造装置が不要であること、数10nm~10μm程度の範囲のSOI 層を有するSOI 基板を同一の

製造装置で製造可能なこと等の点で優れている。

【0007】更に、本出願人は、特開平7-302889号公報において、上記の第一の基板と第二の基板とを貼り合わせた後に、第一の基板を破壊することなく第二の基板から分離し、その後、分離した第一の基板の表面を平滑にして再度多孔質層を形成することで、第一の基板を再利用する技術を開示した。当該公報に開示された方法の1例を、図12(a)～図12(c)を用いて説明する。第1のSi基板1001の表面層を多孔質化して多孔質層1002を形成したのち、その上に単結晶Si層1003を形成し、この単結晶Si層と第一のSi基板とは別の第2のSi基板1004の主面とを絶縁層1005を介して貼り合わせる(図12(a))。この後、多孔質層で貼り合わせたウエハを分割し(図12(b))、第2のSi基板側の表面に露出した多孔質Si層を選択的に除去することにより、SO<sub>2</sub>基板を形成する(図12(c))。第一のSi基板1001は、残留した多孔質層1002を除去して再利用することができ、

【0008】特開平7-302889号公報に開示された発明は、多孔質シリコン層の構造が、非多孔質シリコンに比べて脆弱である点を利用して基板を分離するものであり、一度半導体基板の作製工程に使用した基板を再度、半導体基板の作製工程に利用できるので半導体基板の低コスト化を図るうえで非常に有用なものである。また、この技術は、第一の基板を無駄なく使用できるため、製造コストを大幅に低減することができ、製造工程も単純であるという優れた利点を有する。

【0009】上記第一の基体（基板）と第二の基体（基板）とを分離する方法としては、加圧、引っ張り、せん断、楔挿入、熱処理、融化、波動印刷、ワイヤカットなどの方法の他、本発明者らが特願平9-75498号や1998年3月25日に米国に出願した出願番号047、327号において提案した流体を分離領域に吹き付けて分離する方法がある。この流体としては、気体及び／又は液体が用いられ、特に水を主成分とする液体を用いたウォータージェットなどが好ましく使用できる。この方法は分離に際し、水が貼り合わせ面を切断する作用だけでなく第一の基体と第二の基体との隙間に均等に入り込んで、分離面全体に比較的均一な分離圧力をかけることができる。又、この方法は気体の場合のようにパーティクルをまき散らさずむしろ洗い流すことができる。これら2点でくさび挿入により分離する方法よりも優れている。特に分離領域の機械的強度を貼り合わせ箇所より脆弱にしておくと、これに流体の流れを吹き付けることにより脆弱な部分のみが破断、破壊または除去され、それ以外の強度が強い部分は破壊されずに残せるという大きな利点がある。

【0010】

「旦那が経世」より「せうしん」より「か」の「たがふ」に「れい」を

わされた複合部材をウォータージェットなどの流体を用いて分離しようとして、流体を複合部材の側面、特に分離領域側面付近に吹き付けた場合、分離領域の強度が強いと、流体の流れが分離領域をなかなか破壊または切断できない場合がある。このような場合には流体の圧力を高めることにより分離できるようになるが、圧力を高くしすぎると貼り合わせ基体の側面から亀裂が内部へ進行していく途中で、分離した基体の片方または両方が分離領域に注入された流体の圧力のために割れることがある。このため分離工程において歩留まり低下が起きることがあった。これを避けるための一つの方法は、分離領域全ての機械的強度をより一層弱くしてより脆弱な構造にしておくことであるが、弱くしすぎると複合部材作成工程途中の加熱過程や洗浄過程、その他の基体の取り扱い中に分離領域が壊れて貼り合わせに至らなかったり、分離領域が崩壊してパーティクルが発生し汚染源になることもある。

【0011】また流体を使わず他の方法によって分離しようとする場合にも基本的には同様の問題が生じるため、分離工程における歩留まりが低下することがある。

【0012】本発明の目的は、分離した基体を酸化する  
ことなく、複合部材を比較的容易に分離することができ  
る複合部材とその分離方法を提供することにある。

【0013】本発明の別の目的は、分館領域の機械的強度を比較的強くでき、分館領域の意図しない崩壊を抑え、パーティクルの発生を抑えた複合部材とその分離方法を提供することにある。

【 〇 〇 一 四 】

【課題を解決するための手段】本発明は、複合部材を分離領域で複数の部材に分配する工程を含む複合部材の分離方法において、分離領域の機械的強度が複合部材の表面に沿った方向に不均一であることを特徴とする半導体基体の製造方法により達成できる。

【0015】特に前記分離領域の内の複合部材周辺部の機械的強度が中央部よりも弱いことが好ましい。また同時に前記分離領域は機械的強度が前記貼り合わせ箇所よりも弱いことが好ましい。

【0016】この分離領域は陽極化成法によって形成された多孔質層やイオン打ち込みにより形成された微少気泡を得ることのできる層などを用いることが出来る。Siウェハなどの半導体基体や石英ウェハなどを上記第一の基体や第二の基体として利用する場合、これらはオリエンテーションフラットやノッチを有してはいるがおおむね円盤状であるからこれら第一の基体と第二の基体とを互いに貼り合わせて成る前記複合部材も概略円盤状である。このような場合には前記分離領域の機械的強度が該複合部材内の中心部で高く周辺部で低くなる不均一性をもち、且つ円周方向にはおおむね均一である方が良好に分離される。複合部材が方形の板状部材の場合は、その角部では一切、或は僅か程度の機械的強度を弱くする

【0017】前記分離領域に、互いに多孔度の異なる部分を形成することによって、機械的強度を不均一にすることが出来る。多孔度を大きくするほど機械的強度は弱くなるので、多孔度を変化させることによって機械的強度を変化させられる。より具体的には多孔度を中央部よりも周辺部で高くすることによってその周辺部での機械的強度を弱くすることが出来る。

【0018】前記分離領域はその厚さを変化させることによって機械的強度を不均一にすることが出来る。前記分離領域の厚さを厚くするほど機械的強度は弱くなるのでその厚さを変化させることによって機械的強度も変化する。従って前記分離領域の多孔質層はその厚さを基体の中央部よりも周辺部で大きくすることによってその周辺部での機械的強度を弱くすることが出来る。

【0019】前記複合部材の分離工程より前の工程では分離が起こらず、分離工程では確実に分離するのに、より適した複合部材を得るためには、前記分離領域を機械的強度の異なる複数の層から形成することがより好ましい。特に上記複数の層からなる前記分離領域の中において多孔度が高い層の厚さを非多孔質単結晶半導体層に隣接する多孔度が低い層の厚さよりも薄くすることが好ましい。上記複数の層はその中のそれぞれの層の構造がその界面において急峻に変化する必要は必ずしも無い。各層の強度や構造は、隣り合う層同士の界面で連続的に変化していたとしても、強度が分離領域全体にわたって均一であるよりは分離し易くなる。

【0020】前記機械的強度の異なる複数の層からなる前記分離領域においては前記多孔度が高い層の多孔度が基体の中央部付近よりも周辺部でより高いことがより好ましい。

【0021】前記機械的強度の異なる複数の層状の領域からなる前記分離領域を形成する場合には、前記多孔度が小さい第1層の厚さを基体の中央部よりも周辺部で大きくすることにより、前記多孔度が大きい第2層の多孔度を基体の中央部よりも周辺部で大きくすることが出来る。

【0022】本発明者らは、良質の多孔質層を形成すべく、陽極化成装置に各層改造を施す実験を行っていた。その時、ある形態の陽極化成装置を用いて多孔質化処理を施した複数のSiウェハの中に多孔度の面内分布をもつSiウェハがあることを見出した。

【0023】また、多孔質層上に非多孔質の層を形成した試料を用意し、その非多孔質層を剥離する実験を行っていたところ、多孔質層の多孔度が比較的低いものであっても、多孔度が比較的高いものより、より容易に剥離できる試料があることがわかった。

【0024】上記2つの知見を基に、後述する実施形態のように多孔度が面内分布をもつ多孔質層において、比較的高多孔度の層が破断又は崩壊すると、比較的低多孔度の層も容易に剥離し、それが高多孔度の部分領域にそれ程

影響を受けない。

【0025】即ち、分離を開始させやすい部材の周辺部に相対的に高多孔度の層がある場合には、その多孔度の絶対値にかかわらず分離が容易になることを見出し、本発明をなすに至ったのである。

【0026】

【発明の実施の形態】図1(a)～図1(c)は本発明の一実施の形態による複合部材の断面図である。

【0027】複合部材は、図1(a)に示すように、第一の基体1と第二の基体2とが互いに貼り合わされて形成されており、その内部には分離領域3が形成されている。ここでは、第一の基体1は、その分離領域3上に形成された層4を、第二の基体2の表面に接触させ貼り合わされており、符号5に示すところに貼り合わせ界面がある。

【0028】分離領域3は、機械的強度が比較的強い部分31と、弱い部分32とを有しており、機械的強度が弱い部分32は複合部材の周辺部(分離領域の周辺部)にある。

【0029】この複合部材を分離する場合、相対的に機械的強度の弱い部分32が複合部材の周辺部に存在する為、先にこの部分32に亀裂又は崩壊が生じ、複合部材は分離し易くなる。

【0030】より詳しく説明するに、図1(a)は、厚さが均一な分離領域3の周辺部に多孔度の高い多孔質体からなる部分32を形成し、中央部に多孔度の低い多孔質体からなる部分31を形成することにより局所的に機械的強度の弱い部分32を周辺部に設けている。図2

(a)は、この複合部材を上面からみた場合の機械的強度の強い部分31と弱い部分32の位置を示している。符号7は必要に応じて設けられるオリエンテーションフラットである。

【0031】また、機械的強度の弱い部分32は、複合部材の外周全てではなく、図2Bに示すように外周部の一部であってもよい。機械的強度の強い部分31の面積を弱い部分32の面積より充分大きくすることが望ましい。

【0032】図1(b)は、均一な多孔度の多孔質体からなる分離領域3の厚さを不均一にすることで、周辺部に機械的強度の弱い部分32を形成したものである。この場合も、分離領域3の平面においては、図2Bに示すように外周部の一部に局所的に形成されてもよい。

【0033】図1(c)は、イオン打ち込みにより、周辺部にイオン注入量の多い部分を形成することで機械的強度の弱い部分32を形成したものである。この場合も図2(b)に示すように局所的にイオン注入量を多くして機械的強度の弱い部分32を外周部の一部に形成することもできる。水素イオンや希ガスイオンを打ち込んで所定の熱処理を行うと微小気泡が生じるので、高濃度にイオン注入された部分を多孔度の高い多孔質体とする



ともできる。

【0034】機械的強度の弱い部分32は、多孔質体の多孔度と厚さとを共に、他の部分より高く、厚くすることで、局部的に形成してもよい。又、多孔質体からなる分能領域に局部的にイオンを打ち込んで、イオン注入された部分の多孔質体を脆弱にして機械的強度を弱くしてもよい。

【0035】即ち、図1(a)～図1(c)に示した構成の特徴部分を適宜組み合わせることも好ましいものである。

【0036】本発明に用いられる第一の基体1としては、Si、ウエハの他に、Ge、SiGe、SiC、GaAs、GaAlAs、InP、GaN等の板状の半導体ウエハが好ましく用いられる。

【0037】第二の基体2としては、第一の基体1と同じ半導体ウエハの他に石英ガラスや樹脂シート等の絶縁性基体や、ステンレス鋼等の金属性基体であってもよい。

【0038】非多孔質の層としては、第一の基体の材料と同じ半導体材料から選択された材料からなる単層又は複数の層が好ましく用いられる。複合材料を分能してSOI基板を作製する場合には、単結晶半導体層であることが望ましい。

【0039】図1(c)に示す層6としては、絶縁体又は導電体等、層4と異なる材料で形成されたものが好ましく用いられる。

【0040】そして、第一及び第二の基体を貼り合わせる場合には、間に絶縁層や接着剤の層を介在させることも好ましいものである。

【0041】図3(a)、図3(b)は、複合部材の面内における機械的強度の分布を相対的に示すグラフである。

【0042】実線107は複合部材の左外周端LE1から中央Oに向かって及び複合部材の右外周端RE1から中央Oに向かって、徐々に機械的強度が増加し、中央Oを含むある位置LE2から位置RE2までの部分が機械的強度が最も強く一定となっている形態である。

【0043】一点鎖線108は、外周部(外周端LE1から位置LE2まで、及び外周端RE1から位置RE2までの部分)と、中央部(位置LE2から位置RE2まで)との間で、断続的に機械的強度が遷移している形態である。

【0044】破線109は、外周端LE1、RE1から中央Oに向けて連続的に機械的強度が増加している形態\*

$$P = \{(M - m) \div M\} \times 100 \quad (\%) \quad (1)$$

ここで、多孔質体の密度mとは、孔を含む多孔質体の見かけの重量Gを、孔を含む多孔質体の見かけの体積Vで※

$$m = G \div V$$

である。実際に、表面側の深さdだけが多孔質体である層に於いては、その基体の多孔質層の多孔度Pを求め、

\*であり、機械的強度は中央Oでのみ最大値をとる。

【0045】本発明においては、複合部材の外周端から中央に向かって、5mm内方の位置から分離領域の外周端までの部分における機械的強度が、中央部における機械的強度よりも局部的に弱くすることが好ましいものである。図3(a)に対応させると、複合部材の外周端から中央に向かって5mm内方の位置が、LE1からLE2の間及び/又はRE2からRE1の間になるように分離領域を薄い層として形成することが望ましいのである。

【0046】更に、大口径の複合部材を外周端から中央に向かって分能していく場合には、複合部材の中央部が望むように分能できないことがある。この場合には、中央に局部的に機械的強度の弱い部分を形成するとよい。

【0047】図3(b)は、そのような形態の一例を示しており、機械的強度の高い部分は周辺部と中央との間、即ちドーナツ状の部分Mである。

【0048】分能領域として、多孔質層を用いる場合には、機械的強度が弱い周辺部の多孔度を20%以上、より好ましくは35%以上とし、多孔度の上限を80%以下にするとよい。機械的強度が強い中央部の多孔度は、周辺部より低ければよいのであるが、望ましくは、5%以上35%未満、より好ましくは5%以上20%未満の範囲内から、周辺部より低くなるように選択するとよい。

【0049】多孔度の差は5%以上、より好ましくは10%以上あれば、周辺部と中央部に、複合部材を容易に分能するに充分な機械的強度の差が得られる。

【0050】また、図3(b)の場合は、符号Mで示す部分が機械的強度が強い部分となるので、分離領域を多孔質体で作る場合には、この部分M即ち、機械的強度が極大値をもつ部分の多孔度を、図3(a)の中央部と同じく、5%以上35%未満、より好ましくは5%以上20%未満と低くすればよい。

【0051】図3(b)における中央Oの多孔度は、部分Mよりも高ければよく、その関係を満たすように20%～80%の範囲から適宜選択するとよい。

【0052】ここで多孔質体の多孔度P(%)とは、多孔質体の見かけの体積の中で孔が占める体積の割合を表す。この多孔度は、前記第1の基体上に形成された多孔質体の密度mと非多孔質体の密度Mを用いて次の式で表される。

【0053】

※除したものであり、

$$(2)$$

には、多孔質層を形成する前の基体の重量A、多孔質層を形成後の前記基体の重量B、多孔質層の密度mを用いて、

た後の基体の重量Bを用いて次式から求めることが出来る。

\* [0054]

\*

$$P = \{ (A - a) \div (A - B) \} \times 100 \quad (3)$$

次に、複合部材の作製方法について述べる。

【0055】まず、S<sub>1</sub>ウェハのような第一の基体1を用意し、その表面又は表面から所定の深さの箇所に分離領域3を形成する。分離領域の形成法としては、陽極化成等により第一の基体1の表面を多孔質化する方法及び/又は水素イオンや希ガスイオンのような基体の構成元素とは異なるイオンをイオン打ち込みすることにより第一の基体1の表面から所定の深さの箇所に注入イオン濃度が最大となるイオン打ち込み層を形成する方法がある。陽極化成の条件やイオン打ち込みの条件を後述手順で制御することにより、機械的強度の弱い部分を周辺部に作る。

【0056】次に、必要に応じて分離領域3上に非多孔質の層4を形成し、第2の基体に貼り合わせる。イオン打ち込みを利用する場合には、第一の基体の表層がそのまま非多孔質の層4となる。多孔質化を利用する場合には、多孔質化された第一の基体1の表面上にスパッタリ

ングやCVDにより層4を形成する。

【0057】そして、非多孔質の層4をS<sub>1</sub>ウェハのような第2の基体に直接或いは必要に応じて絶縁層6を介して貼り合わせる。こうして、複合部材が出来上がる。

【0058】この様な局所的に機械的強度の弱い多孔質層を形成するための一つの方法は、陽極化成の電流密度を面内で変化させることである。半導体基体の周辺部に流入する化成電流密度を基体の周辺部において高くすることにより、前記多孔質層の基体の周辺部における厚さ及び/又は多孔度を、基体の中央部より厚く、高くする

ことが出来る。上記のような電流密度分布を実現するためには、例えば、陽極化成の際、化成される基体の近傍における陽極化成液中の、イオン電流が流れる断面荷を、化成する基体の面積よりも、大きくすることである。これによって、基体周辺部に流入する化成電流の面密度を基体中央に流入する化成電流の面密度よりも大きくすればよい。具体的には使用する陽極化成槽を化成する基体よりも大きくして、基体の面積より広い断面荷のイオン電流を、基体で受けるようにすればよい。

【0059】図4は陽極化成に用いられる装置を概念的に示したものである。図4において、101は陽極化成用のDC電源、102はカソード電極、103はアノード電極である。104、105は被処理基体1を保持する絶縁性の保持体であり、凹部に基体1をかみ合させている。106は絶縁性の層底部である。

【0060】ここで、電極102、103の面積は、基体1の面積の1.2倍〜3.0倍、より好ましくは1.3倍〜2.0倍程度である。

【0061】この様にすると基体の外周端より外側から

辺部により多く流れ込み、その部分の多孔質層の厚さを大きく、多孔度を高くすることが出来る。

【0062】更には、複数段階の陽極化成を行い第1の多孔質層の周辺部の厚さを中央部より厚くし、これによりその後に形成する第2の多孔質層の周辺部の多孔度を、中央部の多孔度より高くすることが可能である。

10 【0063】この様な流入電流の分布を、さらに精密に制御する必要がある場合には、化成する基体近傍に基体表面に流入するイオン電流分布を制御する電流ガイドを設けて、イオン電流分布を制御することにより前記多孔度の小さい層の厚さの分布を制御することが出来る。

【0064】前記分離領域として前記イオン打ち込みにより形成された微小気泡 (microcavity) を得ることのできる層を用いる場合には、イオン打ち込みの密度を高くすることにより、上記微小気泡の大きさや密度、微小気泡の分布する厚さなどを大きくすることが出来る。これによりこの領域の機械的強度を小さく出来る。

【0065】そこで基体周辺部のイオン注入量を基体中央部より大きくすることにより基体周辺部の単位体積あたりの微小気泡密度を高め多孔度を基体中央部より高くすることが可能である。

【0066】図5は、図4に示したような方法によって得られる多孔質の多孔度の直径方向に関する面内分布を示すグラフである。

【0067】本グラフから、多孔度が高くなる程、機械的強度は弱くなるので、図3(a)の実線107と比べて、この図5の実線207と点線209とは上下逆のパターンになっている。

【0068】基体の面積に対する電極102、103の面積の比が十分大きいと実線207のようになり、基体の面積に対する電極の面積の比が小さいと破線209のようになる傾向がある。こうして周辺部に高多孔度の多孔質層を形成することができる。

【0069】一方、図1(a)や図3(a)の一点鎖線11に示すような機械的強度分布の多孔質層を作る手法について述べる。その第1の方法は次のとおり、基体1の外周部にのみイオン注入用のマスクとなるホトレジストパターンを設け、中央部に酸素イオンを注入する。外周部の酸素イオン濃度が局所的に低くなった基体に基体とはほぼ同じ面積の電極を用いた陽極化成を施し、外周部が高多孔度で中央部が低多孔度の多孔質層を作る。

【0070】第2の方法は次のとおり、基体の外周部を除いて中央部をワックス等の耐陽極化成マスクで覆い、高電流密度の条件下で一時的な陽極化成を行い外周部を多孔質化する。

【0071】次に、外周部をマスクして低電流密度の条件下で一時的な陽極化成を行い中央部を多孔質化する

【0072】第3の方法は、一般的に陽極化成により均一な多孔質層を形成した後、イオン打ち込みにより外周部のみ、多孔度を高める方法もある。イオン注入量分布を制御すれば、図3(a)、図3(b)に示すような強度分布をもつ多孔質層を制御性良く形成できる。

【0073】但し、製造コストの点ではこれらの方法よりは図4に示した方法の方が有利であろう。

【0074】次に、図1(c)に示した複合部材の作製方法についてより具体的に述べる。

【0075】Siウエハのような基体を酸化して絶縁膜6を形成する。水素又は希ガスイオンを基体全面に所定の加速電圧でイオン打ち込みする。外周部を除く中央部をホトレジストマスクパターンで覆い、外周部に再び同じ加速電圧でイオンを打ち込む。こうして、機械的強度の弱い部分32をもつ分離領域3が形成できる。

【0076】マスクパターンを除去して、第二の基体2に絶縁膜6を貼り合わせる。1回目のイオン打ち込みにおけるドーズ量を2回目のイオン打ち込みにおけるドーズ量をそれぞれ $10^{11}\text{cm}^{-2} \sim 10^{12}\text{cm}^{-2}$ として、機械的強度が弱い部分の真価原子濃度を $10^{10}\text{cm}^{-3} \sim 10^{11}\text{cm}^{-3}$ にすればよい。

【0077】次に、本発明に用いられる複合部材の分離方法について説明する。一例として図1(a)に示した複合部材を分離する形態について説明するに、図6

(a)に示すように、熱処理等により発生した内部応力や、外力を利用して複合部材を分離する。分離領域3のうち周辺部32は機械的強度が局所的に弱い為、ここが最初に崩壊したり、ここに最初に亀裂が生じる。図6(a)は楔110を挿入して第一の基体1の周辺部を第二の基体2から引き離す力111を加えて分離する様子

を示している。

【0078】そして、複合部材は図6(b)に示すように2つに分割される。非多孔質の層4上に残留する分離領域3の残留層37が比較的厚い場合には、研磨やエッチングにより残留層を除去する。そして、必要に応じて水素雰囲気中で熱処理(水素アニール)を行う。こうして、図6(c)に示すように平滑な表面を有する層4を備えた基体2が得られる。

【0079】太陽電池の用途等の場合には、残留層を除去しなくてもよい。

【0080】本発明に使用可能な前記複合部材の分離方法としては、特開平7-302889号に開示されているような加圧、引っ張り、せん断、楔挿入、熱処理、波動印加、ワイヤカットなどの種々の方法や、特開平9-75498号にて提案したような、貼り合わされた前記第一の基体と第二の基体を前記分離領域の側面付近に流体を吹き付けることにより、貼り合わせ界面とは異なる分離領域において複数の部材に分離する方法が使用可能である。

【0081】本発明において分離を行うために用いられ

体の流れは加圧した流体を細いノズルから噴射することにより実現可能である。噴射する流れをより高速、高圧の細いビームにする為の方法としては「ウォータージェット」第1巻1号第4ページなどに紹介されているような流体ジェット法を使用することが出来る。本発明に使用可能な流体ジェットは、高圧ポンプにより加圧された $100 \sim 3000\text{kgf/cm}^2$ の高圧の液体を $0.1 \sim 0.5\text{mm}$ 程度の直径の細いノズルから噴射することによって、セラミックス、金属、コンクリート、樹脂、ゴム、木材などの切断(ただし、固い材料の場合は水に研磨剤を加える)、加工、表層の塗膜の除去、部材表面の洗浄などを行うことができる。従来のウォータージェットの使い方においては、上記のように材料の一部を除去することが主な効果であった。すなわち、ウォータージェット切断は主部分のきりしろを除去すること、また、塗膜の除去、部材表面の洗浄は不要な部分を除去することであった。

【0082】本発明の流体の流れの形成方法として、ウォータージェットを用いる場合、前記分離領域の側面にウォータージェットを噴射することにより、複合部材を分離することが可能である。この場合、先ず貼り合わせ基体の側面に前記分離領域側面を露出させて、そこ及びその周辺に、直接ウォータージェットを噴射する。するとそれぞれの基体は、損傷を受けず機械強度が脆弱な分離領域のみがウォータージェットにより除去されて二枚の基体が分離される。また何らかの理由で前記分離領域側面が予め露出しておらず、酸化膜のような薄い層でその部分が覆われている場合でも、ウォータージェットでまず分離領域を覆う層を除去した後、ウォータージェットで分離できる。

【0083】また、従来のウォータージェットでは利用されていなかった効果ではあるが、複合部材の側面の凹部にジェットを噴射することにより、貼り合わせウェハを構造が脆弱な前記分離領域を押し並べて破壊して分離することも出来る。この場合、分離領域の切断くすがほとんど発生しないし、分離領域が素材としてはジェットそのものでは除去できないものであっても、研磨材を使用することなく、また分離の表面にダメージを与えることなく分離することが可能である。

【0084】この様に、この効果は切断とか研磨といった効果ではなく、流体による図6(a)に示したものと同一程度の楔の効果と考えることも出来る。従って、この効果は貼り合わせ基体の側面に凹部があってジェットを噴射することにより、分離領域を引き剥がす方向に、力が掛かる場合には大いに効果が期待できる。この効果を充分に発揮させようとするならば、複合部材の側面の形状は凸型ではなく凹型である方が好ましい。

【0085】図7は本発明に用いられる半導体基体の製造方法に用いられるウォータージェット装置の一例を示

ウェハを貼り合せ一体化した複合部材で、内部に分離領域3が存在する。403、404は真空チャックにより複合部材1を吸着／固定する保持具で、互いに同一回転軸上に存在する。更に保持具404は、ベアリング408を介して支持台409と接続し、後屋でスピードコントロールモータ410が直結して接続されていることで、任意のスピードで回転することができる。また、保持具403はベアリング411を介して支持台409と接続し、後屋で支持台409との間に圧縮バネ412を介することで保持具403が複合部材1から離れる方向

10 YAに力がかかっている。  
【0086】まず、複合部材1を位置決めピン413にならう様にセットし、保持具404に吸着／保持させる。保持具404は、複合部材1を位置決めピン413にならわすことで、複合部材1中央部を保持することができる。次に、保持具403を複合部材1が、吸着／保持するまでベアリング411にならうて左方向に前進させる。この時、保持具403は、圧縮バネ412により右方向に力がかかる。このとき、圧縮バネ412による力で、複合部材1から保持具403が離れない様、圧縮バネ412の戻る力と、保持具403が複合部材1を吸引する力はバランスを取っている。

20 【0087】次に、ウォータージェットポンプ414からウォータージェットノズル402に水を送り込み、噴出する水が安定するまで一定時間出し続ける。水が安定したら、シャッタ406を開いて複合部材1の側面にウォータージェットノズル402から噴出した水（以下ウォータージェット水）をあてる。この時、保持具404を回転させることにより、複合部材1及び保持具403を回転させる。ウォータージェット水は、複合部材1の側面において、その厚さの中心近くにあてることで、複合部材1を外周部から中心に向かって2体に押し広げ、複合部材1内で比較的弱い分離領域を破壊し、最終的には2体に分離する。

【0088】この時、上述した様に、複合部材1にウォータージェット水は均等にかかり、また、保持具403は、複合部材1を保持しながら、右方向に力が働いているので、分離した後、分離した複合部材1同士が揺動しない様になっている。

40 【0089】また使用する流体として、水を使用せず、アルコールなどの有機溶媒やフッ酸、硝酸などの酸、あるいは水酸化カリウムなどのアルカリその他の分離領域を選択的にエッチングする作用のある液体なども使用可能である。さらに流体として空気、窒素ガス、炭酸ガス、希ガスなどの気体を用いても良い。分離領域に対してエッチング作用を持つガスやプラズマを用いることもできる。使用する水は半導体基体の製造工程に導入する複合部材の分離方法の為に、不純物金属やパーティクル等を極力除去した純水、超純水などの純度の高い水を使用することが望ましい。また、完全低圧プロセスである

ので純水以外の流体ジェットを用いても、分離後に洗浄すれば、不純物やパーティクルは除去することも充分可能である。

【0090】この様な流体を吹き付ける方法を用いる場合には、前記複合部材の分離領域付近に、液体の流れを受けて分離領域を押し広げる方向の力を生ずるような、凹型にへこんだ形状を持たせておくことが好ましい。分離領域を挟んで二枚の基体が貼り合わさってなる複合部材を分離領域で分離しようとする場合には、それぞれの基体のエッジを面取りしておくことにより容易にこの様な構造を実現することが出来る。

【0091】ウォータージェットの様な流体の流れにより、または加圧、引っ張り、せん断、楔挿入、熱処理、波動印加、ワイヤカットその他の種々の方法を利用することにより、複合部材にあらかじめ形成してある分離領域に分離力を加えて二つに分離する場合、分離領域の機械的に脆弱な部分が破壊されることにより分離が進行する。分離領域付近に流体の流れを噴射した場合にも機械的強度が脆弱な分離領域を流体の流れが除去または破壊していく。しかも流体の場合には基本的には分離領域が除去されつつそれ以外の脆弱でない部分は破壊されずに残るので、結果として分離後に利用する部分を傷つけずに分離できるという利点がある。しかしながらいずれの方法の場合にも、分離領域の強度が十分に弱くなっていないと分離領域を破壊できない場合がある。例えば所定の圧力の流体の流れでは分離領域を破壊、または除去出来ないことがある。

30 【0092】これを解決するために、流体の圧力を高めると分離領域だけでなくそれ以外の部分まで破壊され、例えば貼り合わせ基体の分離の場合に、板状の第一または第二の基体が割れることがある。これを防ぐために流体の圧力を下げると分離が出来ないというジレンマが生じる。

【0093】上記の大部分の分離方法では、分離の初期段階に複合部材の中に形成された分離領域の表面付近、例えば円板状の貼り合わせ基体の周辺部に形成された部分の分離領域に固体のくさびを押し込む必要がある。このように分離は表面から進行させる必要がある場合が多い。ところが表面に近い部分は分離が進行しない間は分離力を加える面積が小さく、力の面積密度を高くせざるを得ないという問題がある。これは分離した面に分離力をかけることは出来るが、まだ分離していない面には分離力をかけられないためである。分離が進行した段階では分離力を加えることの出来る面積が増えるので分離面にかかる分離力を大きくして分離し易くしてもその面密度が低くなるため分離に伴う基体の破損（割れなど）を防ぐことが容易になる。

【0094】分離の初期において、分離を容易にするためには分離領域の多孔質層の多孔度を高める、多孔質層の厚さを厚くする、あるいはイオン交換樹脂を挿入す

ることによって、微小気泡の形成量を増やす、などの方法により、機械強度を弱くすればよいが、強度が弱くなり過ぎると、前記複合部材の形成工程の途中で分層工程に達する前に分層領域が破壊されるという不都合が生じる。

【0095】本発明者らが鋭意研究の結果、このような不都合を避けるためには、分層領域の機械強度を貼り合わせ面と平行な方向に変化させ、特に前記分離領域の貼り合わせ基体表面に近い部分、例えば周辺部の機械強度を基体中央部に比べて弱くすればよいことが判明した。

【0096】分層の初期段階で分離した面の面積が小さく分層力を大きく出来ない段階では、分離領域の機械強度を弱くして小さな力で分層が進行するようにする。基体の周辺部付近の分離領域の機械強度を小さくすることによりこれは可能である。基体の中央部では分層領域の機械強度を周辺部よりも高くして工程途中で割れを防ぐ。

【0097】こうしておいても分離が中央部にさしかかるときには分離した面積が広いので分層力の面密度を小さくしても分層力全体は大きくなり分層を進行させることが出来るようになる。この様な効果は分離方法によらず発現されるものであるが分離した面全体に比較的均一に分層力をかけて基体の破壊を防ぐためには上記流体の流れを分離領域に噴射する方法が最も望ましい。

【0098】分層を安定して行うための条件範囲を広くして基体の破壊無しに確実に分離を行うためには、図8のように分離領域3が機械的強度の異なる複数の層状の領域(22, 23)から成る構造が好ましい。この様な場合には基体の中央部に比べて周辺部での機械強度を小さくすることが比較的容易に実現できる。分離領域が多孔度の小さい層23(これを便宜上多孔質層第一層と称する。)と、大きい層22(これを便宜上多孔質層第二層と称する。)との積層構造になっている場合、多孔度の小さい層23をまず陽極化成法により形成し、しかる後化成電流を大きくして多孔度の大きい層22を同じく陽極化成法により形成すればよい。

【0099】本発明者らが鋭意研究したところによると、上記多孔質層第二層22の多孔度は電流の大きさだけで決まっているのではなく、上記多孔質層第一層23の膜厚や多孔度にも依存していることが分かった。上記多孔質層第二層22の化成電流を等しく設定しても、上記多孔質層第一層23の膜厚が厚いか多孔度が低いと、上記多孔質層第二層22の多孔度が高くなる傾向がある。このため例えば上記多孔質層第一層23の厚さを薄くしていくと、上記多孔質層第二層22の多孔度を高く保つには、多孔質層第二層22の化成電流をより高くする必要がある。この関係を示したものが図9である。

【0100】もし多孔質層第二層の化成電流を一定に保てば、多孔質層第一層の厚さが変わると多孔質層第二層の多孔度が比例変化する。この関係を示したものが図10

である。図10によれば、第一層膜厚(ミクロン)に対する第二層の多孔度(%)の関係図であり、多孔質層第一層を形成した後、これとは独立に多孔質層第二層を形成できるのではなく、多孔質層第一層の特性が多孔質層第二層の多孔度に影響を与えることは明らかである。このような現象の詳細なメカニズムは完全には解明できていない。しかし後述することく、多孔質Siの形成には化成液中のF<sup>-</sup>イオンが必要とされており、孔の先端の孔形成部でF<sup>-</sup>イオンが消費されれば、多孔質Siの表面側から孔内を通して、新たなF<sup>-</sup>イオンが輸送されて孔の先端に供給される必要がある。

【0101】このような孔内のF<sup>-</sup>イオンの電界または拡散による輸送の実効的な易動度は、第一層の孔サイズや孔の長さすなわち第一層の厚さに依存すると考えられる。すなわち陽極化成によって形成される多孔質層第一層自身がその先の多孔質層形成に必要なイオンの輸送を制限する。

【0102】したがって、形成された多孔質層第一層がその先の多孔質層の形成に必要なF<sup>-</sup>イオン輸送の実効的な易動度制限層として働く。化成電流が一定なら相当の厚さまで多孔度が余り変わらずに化成が進行する。これは一定の電流ではF<sup>-</sup>イオンの消費と供給のバランスで決まるあるサイズの孔が形成されるが、途中で電流を増やすと、すでに形成済みの多孔質層の存在によりF<sup>-</sup>イオンの消費と供給のバランスが変わって孔のサイズが大きく変化するためと考えられる。

【0103】第一層の厚さが増加して、その中を輸送されるF<sup>-</sup>イオンの実効的な易動度が下れば、孔の先端でのF<sup>-</sup>イオン濃度が低下し、孔の内の化成液中にイオン欠乏層が広がることによって、化成液と孔内のSi単結晶表面との界面のポテンシャル障壁が低くなる部分が広がり、そこでSiがエッチングされて孔のサイズが増加している可能性がある。

【0104】実際、化成電流を単純に大きくしても、Si表面に易動度制限層が存在しなければ、多孔度は余り増大せず、むしろ化成速度が増大してしまう。従って化成電流の増大により、多孔度を大きく変化させようとする場合には、多孔度増大層と化成液との間に上記のような何らかのF<sup>-</sup>イオンの易動度制限層が必要である。そこでもし上記多孔質層第一層の厚さが、基体周辺で厚く出来れば、その部分の多孔質層第二層の多孔度は、中央部の第一層の厚さが薄い部分の第二層の多孔度よりも大きくすることが出来、これにより基体周辺部の分層領域の機械的強度を弱くすることが可能になる。

【0105】本発明はこの様に陽極化成のメカニズムを巧みに利用し、前記機械的強度の異なる複数の層状の領域からなる前記分離領域を形成する場合に、前記多孔度が小さい層23の厚さを基体の中央部よりも周辺部で大きくすることにより、前記多孔度が大きい層22の多孔度を基体の中央部よりも周辺部で大きくすることが可能になる。

る点にも大きな特徴がある。

【0106】そして、前述したとおり、図4に示すような簡略的な装置を用いた陽極化成方法により、ウェハに多孔質層を形成することができる。こうして多孔度の小さい層の基体周辺部の厚さを基体中央部より厚くし、これによりその後形成する多孔度の大きな層の基体周辺部の多孔度を、基体中央部の多孔度より大きくすることが可能である。この様な流入電流の分布を、さらに精密に制御する必要がある場合には、化成する基体近傍に基体表面に流入するイオン電流分布を制御する電流ガイドを設けて、イオン電流分布を制御することにより前記多孔度の小さい層の厚さの分布を制御することが出来る。

【0107】また、第一の基体と第二の基体の接合部材からウェハと薄膜半導体とを分離するためのウォータージェット噴射装置については、上述の図7に示して説明したとおりである。

【0108】次に、図8は、上述したように、本発明の方法に使用することの出来る貼り合せ基体の構造の一例を詳しく説明するための図である。この例では、分離領域3は、図8に示すように、多孔度の低い多孔質第一層23と、これよりも多孔度が高く機械強度が弱い多孔質第二層22からなる二層構造になっている。本発明においては、上記多孔質第二層22は基体の周辺部付近での多孔質を中央部よりも高くしたり、その厚さを厚くしたりすればよい。分離は貼り合わせ界面とは異なる位置にある多孔質第二層22の中又はその界面に亀裂が生じる。多孔質第二層22はその機械的強度が弱いので、第一の基体21と第二の基体27が分離する方向に力が加わると、多孔質第二層22のみが破壊されて両者が分離する。この時、多孔質第一層23は、非多孔質の単結晶Siからなる層4を形成する際に、結晶欠陥の発生を抑えるために、また分離工程で層4に破壊が及ばないための保護層として必要である。もちろん多孔度をそれほど高くしなければ多孔質第二層22を形成することなく分離を行うことも可能であるが、好ましくは多孔質第二層22を有していたほうが歩留まりがよい。

【0109】

【実施例】次に、各実施例により、本発明の内容をさらに具体的に説明する。

【0110】【実施例1】本実施例では、625 $\mu$ mの厚みを持った比抵抗0.01 $\Omega$ ・cmのP型（あるいはN型でもよい）の8インチ径の第1の（100）単結晶Si基板を用いて、HF溶液中において陽極化成を行った。陽極化成層の化成電極及び上記Si単結晶基体と平行な面の断面積を該Si基体の面積の約2倍と成るように化成槽を作成し、これを使用した。

【0111】陽極化成条件は以下のとおりである。

【0112】化成電流：2.6(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1

時間：11(分)

このようにして化成した基体の多孔質層の中央部の厚さは約12ミクロンで中央部の多孔度は約20%。周辺部の多孔質層の厚さは最大で約19ミクロンで多孔度は30%であった。この様な条件で作成したものの周辺部の孔の大きさは電子顕微鏡観察によって調べることが出来る。表面から深い部分では中央部に比べ明らかに大きい。ただし多孔質層の表面付近では中央部も周辺部も孔の大きさに顕著な差は見られない。このことは後の工程で多孔質層に欠陥の少ないSiの単結晶をエピタキシャル成長させる上で非常に大切である。

【0113】この基板を酸素雰囲気中400℃で1時間酸化した。この酸化により多孔質Siの孔の内壁は熱酸化膜で覆われた。フッ酸で洗浄を行い、次いで水素雰囲気中950℃の熱処理を行った後、多孔質Si上に以下の条件のCVD法により単結晶Siを0.3 $\mu$ mエピタキシャル成長した。

【0114】ソースガス：SiH<sub>4</sub>

キャリアーガス：H<sub>2</sub>

温度：900℃

圧力：1 $\times 10^{-4}$ Torr

成長速度：3.3nm/sec

さらに、このエピタキシャルSi層表面に熱酸化により100nmのSiO<sub>2</sub>層を形成した。

【0115】該SiO<sub>2</sub>層表面と別に用意したSi基板の表面とを重ね合わせ、接触させた後、1180℃で5分間の熱処理をし、貼り合わせをおこなった。接合部材を図7に示した装置にセットし、水圧1000kgf/cm<sup>2</sup>、直径0.15mmの条件でウォータージェット噴射を行ったところ多孔質Si層が破断し、ウェハは良好に二分割され、2つのSi基板が分離面に多孔質Siが表出した。その後、多孔質Si層をHF/H<sub>2</sub>O<sub>2</sub>/C<sub>2</sub>H<sub>5</sub>OH系のエッチング液で選択エッチングする。多孔質Siは選択エッチングされ完全に除去された。非多孔質Si単結晶の該エッチングに対するエッチング速度は、極めて低く、非多孔質層におけるエッチング量は実用上無視できる。すなわち、Si酸化膜上に0.2 $\mu$ mの厚みを持った単結晶Si層が形成できた。多孔質Siの選択エッチングによっても単結晶Si層には何ら変化はなかった。

【0116】こうして得られたSiO<sub>2</sub>基板を水素雰囲気中で熱処理した。

【0117】透過電子顕微鏡による断面観察の結果、Si層には新たな結晶欠陥は導入されておらず、良好な結晶性が維持されていることが確認された。エピタキシャルSi層表面に酸化膜を形成しなくても同様の結果が得られる。第1のSi単結晶基板は残留多孔質Siを除去して、もう1枚のSiO<sub>2</sub>基板を得るために再度第1のSi単結晶基板として使用した。

厚みを持った比抵抗 $0.01\Omega\cdot\text{cm}$ のP型（あるいはN型でもよい）の8インチ径の第1の（100）単結晶Si基板を、HF溶液中において陽極化成を行う。陽極化成層の化成電極及び上記Si単結晶基板と平行な面の断面積を該Si基板の面積の約2倍と成るように化成槽を作成し、これを使用した。

【0119】陽極化成条件は以下のとおりである。

【0120】化成電流：2.6(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1  
時間：11(分)

このようにして化成した基体の多孔質層第一層の中央部の厚さは約12ミクロンで中央部の多孔度は約20%となった。周辺部の多孔質層の厚さは最大で約19ミクロンで多孔度は30%であった。続いて第一層化成後第二層の化成を下記の条件で引き続いておこなう。

【0121】電流密度：8(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1  
時間：2(分)

第一層形成後に上記のような条件で第二層の化成を行うと第二層の中央の膜厚は約2ミクロン、多孔度は40%程度となった。しかし基体の周辺部では多孔度は最大55%程度、その厚さは2ミクロン未満である。

【0122】ただし多孔質層第一層の表面付近では中央部も周辺部も孔の大きさに顕著な差は見られない。このことは後の工程で多孔質層状に欠陥の少ないSiの単結晶をエピタキシャル成長させる上で非常に大切である。

【0123】この基板を酸素雰囲気中400℃で1時間酸化した。この酸化により多孔質Siの孔の内壁は熱酸化膜で覆われた。次に、HF溶液で洗浄を行い、酸素雰囲気中で熱処理を行った後、多孔質Si上にCVD法により単結晶Siを0.3μmエピタキシャル成長する。成長条件は以下の通りであった。

【0124】ソースガス：SiH<sub>4</sub>

キャリアーガス：H<sub>2</sub>

温度：900℃

圧力： $1\times 10^{-4}$ Torr

成長速度：3.3nm/sec

さらに、このエピタキシャルSi層表面に熱酸化により100nmのSiO<sub>2</sub>層を形成した。

【0125】該SiO<sub>2</sub>層表面と別に用意したSi基板の表面とを重ね合わせ、接触させた後、1180℃で5分の熱処理をし、貼り合わせをおこなう。こうして得られた複合部材の模式的断面図を、図11に示す。図11によれば、複合部材は、第一の基板1と第二の基板2との間に、酸化膜6と、単結晶Si層4と、多孔質第一層23と、多孔質第二層22とがそれぞれ層をなし、多孔質第一層23の中央部分35と、その周辺部分36と、多孔質第二層22の中央部分33と、その周辺部分34とからなる状態を示している。

【0126】この図11によれば、内層の膜面に多孔質層

を表出させ、多孔質Siをある程度エッチングし、そこへ剃刀の刃のように鋭利な板を挿入したところ、多孔質Si層が破断しウェハは二分割され、多孔質Siが表出した。その後、多孔質Si層をHF/H<sub>2</sub>O<sub>2</sub>/C<sub>2</sub>H<sub>5</sub>OH系のエッチング液で選択エッチングする。多孔質Siは選択エッチングされ完全に除去された。非多孔質Si単結晶の該エッチング液にたいするエッチング速度は、極めて低く、非多孔質層におけるエッチング量は実用上無視できる膜厚減少である。すなわち、Si酸化膜上に0.2μmの厚みを持った単結晶Si層が形成できた。多孔質Siの選択エッチングによっても単結晶Si層には何ら変化はなかった。こうして得られたSiO<sub>2</sub>基板を酸素雰囲気中で熱処理した。

【0127】透過電子顕微鏡による断面観察の結果、Si層には新たな結晶欠陥は導入されておらず、良好な結晶性が維持されていることが確認された。エピタキシャルSi層表面に酸化膜を形成しなくても同様の結果が得られた。第1のSi単結晶基板は残留多孔質Siを除去して、再度第1のSi単結晶基板として使用した。

【0128】【実施例3】本実施例では、625μmの厚みを持った比抵抗 $0.01\Omega\cdot\text{cm}$ のP型（あるいはN型でもよい）の8インチ径の第1の（100）単結晶Si基板を、HF溶液中において陽極化成を行った。陽極化成層の化成電極及び上記Si単結晶基板と平行な面の断面積を該Si基板の面積の約2倍と成るように化成槽を作成し、これを使用した。

【0129】陽極化成条件は以下のとおりである。

【0130】化成電流：2.6(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1  
時間：11(分)

このようにして化成した基体の多孔質層第一層の中央部の厚さは約12ミクロンで中央部の多孔度は約20%、周辺部の多孔質層の厚さは最大で約19ミクロンで多孔度は30%であった。第一層化成後第二層の化成を下記の条件で引き続いて行った。

【0131】電流密度：8(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1  
時間：2(分)

第一層形成後に上記のような条件で第二層の化成を行うと第二層の中央の膜厚は約2ミクロン、多孔度は40%程度であった。しかし基体の周辺部では多孔度は最大55%程度、その厚さは2ミクロン未満であった。

【0132】ただし多孔質層第一層の表面付近では中央部も周辺部も孔の大きさに顕著な差は見られない。このことは後の工程で多孔質層状に欠陥の少ないSiの単結晶をエピタキシャル成長させる上で非常に大切である。

【0133】この基板を酸素雰囲気中400℃で1時間酸化した。この酸化により多孔質Siの孔の内壁は熱酸化膜で覆われた。HF溶液で洗浄し、酸素雰囲気中で熱



を0.3 $\mu$ mエピタキシャル成長する。成長条件は以下の通りである。

【0134】ソースガス：SiH<sub>4</sub>

キャリアーガス：H<sub>2</sub>

温度：900℃

圧力：1×10<sup>-4</sup>Torr

成長速度：3.3nm/sec

さらに、このエピタキシャルSi層表面に熱酸化により100nmのSiO<sub>2</sub>層を形成した。

【0135】該SiO<sub>2</sub>層表面と別に用意したSi基板の表面とを重ね合わせ、接触させた後、1180℃で5分間の熱処理をし、貼り合わせをおこなう。こうして、上述した図11のような複合部材を得た。ウェハ側面に水圧300kgf/cm<sup>2</sup>、直径0.1mmの条件でウォータージェット噴射を行ったところ多孔質Si層が破断しウェハはきわめて良好に二分割され、多孔質Siが表出する。その後、多孔質Si層をHF/H<sub>2</sub>O<sub>2</sub>/C<sub>2</sub>H<sub>5</sub>OH系のエッチング液で選択エッチングする。多孔質Siは選択エッチングされ完全に除去された。非多孔質Si単結晶の該エッチング液に対するエッチング速度は、極めて低く、非多孔質層におけるエッチング量は実用上無視できる膜厚減少である。すなわち、Si酸化膜上に0.2 $\mu$ mの厚みを持った単結晶Si層が形成できた。多孔質Siの選択エッチングによっても単結晶Si層には何ら変化はなかった。こうして得られたSOI基板を水素雰囲気中で熱処理した。

【0136】透過電子顕微鏡による断面観察の結果、Si層には新たな結晶欠陥は導入されておらず、良好な結晶性が維持されていることが確認された。エピタキシャルSi層表面に酸化膜を形成しなくても同様の結果が得られた。第1のSi単結晶基板は残留多孔質Siを除去して、再度第1のSi単結晶基板として使用した。

【0137】【実施例4】本実施例では、625 $\mu$ mの厚みを持った比抵抗0.01 $\Omega$ ・cmのP型あるいはN型の8インチ径の第1の(100)単結晶Si基板を、HF溶液中において陽極化成を行った。陽極化成層の化成電極及び上記Si単結晶基板と平行な面の断面積を該Si基板の面積の約1.3倍と成るように化成槽を作成し、これを使用した。

【0138】陽極化成条件は以下のとおりである。

【0139】化成電流：2.6(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1

時間：11(分)

このようにして化成した基体の多孔質層第一層の中央部の厚さは約6 $\mu$ mで中央部の多孔度は約20%であった。周辺部の多孔質層の厚さは最大で約8 $\mu$ mで多孔度は25%であった。第一層化成後第二層の化成を下記の条件で引き続いておこなう。

【0140】電流密度：12(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1

時間：1(分)

多孔質層第一層の表面付近では中央部も周辺部も孔の大きさに顕著な差は見られない。このことは後の工程で多孔質層上に欠陥のないSiの単結晶をエピタキシャル成長させる上で非常に大切である。

【0141】この基板を酸素雰囲気中400℃で1時間酸化した。この酸化により多孔質Siの孔の内壁は熱酸化膜で覆われた。HF溶液で洗浄し、水素雰囲気中で熱処理した後、多孔質Si上にCVD法により単結晶Siを0.3 $\mu$ mエピタキシャル成長させた。成長条件は以下の通りである。

【0142】ソースガス：SiH<sub>4</sub>

キャリアーガス：H<sub>2</sub>

温度：900℃

圧力：1×10<sup>-4</sup>Torr

成長速度：3.3nm/sec

さらに、このエピタキシャルSi層表面に熱酸化により100nmのSiO<sub>2</sub>層を形成した。

【0143】該SiO<sub>2</sub>層表面と別に用意したSi基板の表面とを重ね合わせ、接触させた後、1180℃で5分間の熱処理をし、貼り合わせをおこなった。ウェハ端面に多孔質層を表出させ、多孔質Siをある程度エッチングすることなく、そこへ水圧300kgf/cm<sup>2</sup>、直径0.1mmの条件でウォータージェット噴射を行うと、多孔質Si層が破断し、ウェハはきわめて良好に二分割され、多孔質Siが表出する。その後、多孔質Si層をHF/H<sub>2</sub>O<sub>2</sub>/C<sub>2</sub>H<sub>5</sub>OH系のエッチング液で選択エッチングした。多孔質Siは実施例3よりも短い時間で選択エッチングされ完全に除去した。非多孔質Si単結晶の該エッチング液に対するエッチング速度は、極めて低く、非多孔質層におけるエッチング量は実用上無視できる膜厚減少である。すなわち、Si酸化膜上に0.2 $\mu$ mの厚みを持った単結晶Si層が形成できた。多孔質Siの選択エッチングによっても単結晶Si層には何ら変化はない。こうして得られたSOI基板を水素雰囲気中で熱処理した。

【0144】透過電子顕微鏡による断面観察の結果、Si層には新たな結晶欠陥は導入されておらず、良好な結晶性が維持されていることが確認された。エピタキシャルSi層表面に酸化膜を形成しなくても同様の結果が得られた。第1のSi単結晶基板は残留多孔質Siを除去して、再度第1のSi単結晶基板として使用した。

【0145】【実施例5】本実施例では、625 $\mu$ mの厚みを持った比抵抗0.01 $\Omega$ ・cmのP型(あるいはN型でもよい)の8インチ径の第1の(100)単結晶Si基板を、HF溶液中において陽極化成を行う。陽極化成層の化成電極及び上記Si単結晶基板と平行な面の断面積を該Si基板の面積の約1.3倍と成るように化成槽を作成し、これを使用した。

【0146】陽極化成条件は以下のとおりである。





【0147】化成電流：2.6(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1

時間：11(分)

このようにして化成した基体の多孔質層第一層の中央部の厚さは約6ミクロンで中央部の多孔度は約20%、周辺部の多孔質層の厚さは最大で約8ミクロン、多孔度は25%であった。第一層化成後第二層の化成を下記の条件で引き続いて行った。

【0148】電流密度：12(A)

陽極化成溶液：HF：H<sub>2</sub>O：C<sub>2</sub>H<sub>5</sub>OH=1：1：1 10  
時間：1(分)

多孔質層第一層の表面付近では中央部も周辺部も孔の大きさに顕著な差は見られない。このことは後の工程で多孔質層上に欠陥の少ないSiの単結晶をエピタキシャル成長させる上で非常に大切である。

【0149】この基板を酸素雰囲気中400℃で1時間酸化した。この酸化により多孔質Siの孔の内壁は熱酸化膜で覆われた。HF溶液で洗浄し、水素雰囲気中で熱処理した後、多孔質Si上にCVD法により単結晶Siを0.3μmエピタキシャル成長させた。成長条件は以下の通りであった。 20

【0150】ソースガス：SiH<sub>4</sub>

キャリアーガス：H<sub>2</sub>

温度：900℃

圧力：1×10<sup>-1</sup>Torr

成長速度：3.3nm/sec

さらに、このエピタキシャルSi層表面に熱酸化により100nmのSiO<sub>2</sub>層を形成した。

【0151】該SiO<sub>2</sub>層表面と別に用意したSi基板の表面とを重ね合わせ、接触させた後、1180℃で5分間の熱処理をし、貼り合わせをおこなう。ウェハ端面に多孔質層を表出させ、多孔質Siをある程度エッチングする。こうして作成した多数枚の貼り合わせ基体を同時超音波照射装置の水槽に沈め50kHz程度の超音波を照射したところすべての貼り合わせ基体の多孔質Si層が破壊しウェハは一挙に二分割され、多孔質Siが表出した。その後、多孔質Si層をHF/H<sub>2</sub>O/C<sub>2</sub>H<sub>5</sub>OH系のエッチング液で選択エッチングする。多孔質Siは実施例3よりも短い時間で選択エッチングされ完全に除去される。非多孔質Si単結晶の該エッチング液に対するエッチング速度は、極めて低く、非多孔質層におけるエッチング量は実用上無視できる膜厚減少である。すなわち、Si酸化膜上に0.2μmの厚みを持った単結晶Si層が形成できた。多孔質Siの選択エッチングによっても単結晶Si層には何ら変化はない。

【0152】透過電子顕微鏡による断面観察の結果、Si層には新たな結晶欠陥は導入されておらず、良好な結晶性が維持されていることが確認された。エピタキシャルSi層表面に酸化膜を形成しなくても同様の結果が得

して、再度第1のSi単結晶基板として使用した。

【0153】【実施例6】本実施例では、第1の単結晶Si基板表面に、絶縁層として熱酸化により200nmの酸化膜(SiO<sub>2</sub>層)を形成した。

【0154】ここで投影飛程がSi基板中になるように、第1の基板表面から第一回目のイオン注入を行った。これによって、分離領域として働く層が、投影飛程の深さの所に微少気泡層あるいは注入イオン相高濃度層による歪み層として形成された。この後第一回目とはほぼ同一の条件で基板の周辺部10mmの範囲に再度イオン注入を行った。これにより周辺部のイオン注入量は中央部の約2倍となった。

【0155】上記イオン注入後、該SiO<sub>2</sub>層表面と別に用意した第2のSi基板の表面とを重ね合わせ、接触させた後、600℃の温度で熱処理をし、貼り合わせを行った。

【0156】上記のようにして形成された貼り合わせ基板を中心部で保持し、中心軸の周りに回転させつつ、周辺部から貼り合わせ面に平行に水圧300kgf/cm<sup>2</sup>、直径0.1mmの条件でウォータージェット噴射を行ったところ前記分離領域が破壊しウェハはきわめて良好に分離された。

【0157】その結果、元々第一の基板表面に形成されたSiO<sub>2</sub>層、表面単結晶層、および分離層の一部が第2の基板側に移設された。第1の基板表面には分離層の残りの部分が残った。上記分離の後上記第2の基板を1000℃でアニールし、その後第2の基板上に移設された分離層をCMP装置で研磨して除去し、表面を平滑化した。

【0158】すなわち、Si酸化膜上に0.2μmの厚みを持った単結晶Si層が形成できる。こうして出来上がった絶縁層上に形成された単結晶Si層の膜厚を面内全面について、100点位置で測定したところ、膜厚の均一性は201nm±7nmであった。

【0159】透過電子顕微鏡による断面観察の結果、Si層には新たな結晶欠陥は導入されておらず、良好な結晶性が維持されていることが確認された。

【0160】さらに水素中で1100℃で熱処理を1時間行い、表面粗さを原子間力顕微鏡で評価したところ、50μm角の領域での平均2点粗さはおよそ0.2nmで通常市販されているSiウェハと同等であった。

【0161】酸化膜は、エピタキシャル層表面でなく、第2の基板表面に形成しても、あるいは、その両者に形成しても同様の結果が得られる。

【0162】また、第1の基板側に残った分離層をエッチング及び表面研磨により再生し、さらに必要に応じて水素アニール等の表面処理を施して再び第1の基板としてあるいは第2の基板として投入することができる。

【0163】本実施例は、元々Siウェハの表面領域を

例であるが、エピタキシャルウェハを用いてエピタキシャル層をイオン注入による分離層を介して、第2の基板に移設してもよい。また、本実施例のイオン注入後に、表面 $SiO_2$ を除去してからエピタキシャル層を形成して、更に $SiO_2$ を形成した後、貼り合わせ工程に入って、エピタキシャル層をイオン注入による分離層を介して第2の基板に移設してもよい。後者の場合は元々 $SiO_2$ ウェハの表面領域も移設されることになる。

【0164】

【発明の効果】上記各実施例によれば、複合部材を分離する場合、分離のための力を高くしても貼り合わせ基体のエッジ部から分離が内部へ進行していく時に、途中で分離した基体の片方または両方が割れることはない。

【0165】また、分離領域が崩壊して発生するパーティクルが工程を汚染することを防止できる。また流体を使わず他の方法によって分離しようとする場合にも、分離の歩留まりを向上できる。

【0166】さらに、貼り合わせた半導体基体その他の複合部材に作り込まれた分離領域から基体を分離する場合に、途中の工程では分離が起こらず、分離工程では確実に分離するのに適した複合部材を形成することができる。

【図面の簡単な説明】

【図1】本発明による複合部材の模式的断面図である。

【図2】本発明による複合部材の上面図である。

【図3】本発明による複合部材の機械的強度の面内分布を示す。

【図4】本発明に用いられる陽極化成法を適用する状態図である。

【図5】本発明による半導体基体の多孔質体の特性図である。

\*【図6】本発明による複合部材の分離方法を示す図である。

【図7】ウォータージェット装置の概念図である。

【図8】本発明による複合部材の断面図である。

【図9】ポーラスの厚さと化成電流の特性図である。

【図10】第一層の膜厚に対する第二層の多孔度の特性図である。

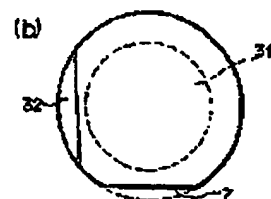
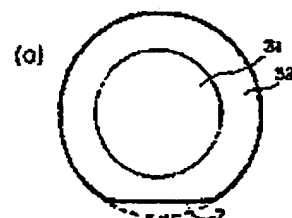
【図11】本発明の一実施例による複合部材の断面図である。

【図12】従来の半導体基板の作製工程を示す図である。

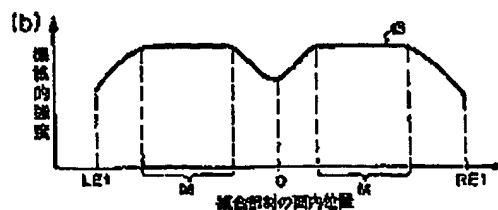
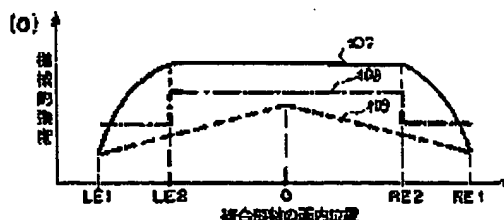
【符号の説明】

- 1 第一の基体
- 2 第二の基体
- 3 分離領域
- 4 単結晶 $Si$ 層
- 5 貼り合わせ界面
- 6 酸化膜
- 11 電源
- 12 陰電極
- 13 陽電極
- 14、15 ウェハホルダー
- 16 ウェハ
- 21 第一の基体
- 22 多孔質第二層
- 23 多孔質第一層
- 24 単結晶 $Si$ 層
- 25 貼り合わせ界面
- 26 酸化膜
- 27 第二の基体
- \* 401 半導体基体

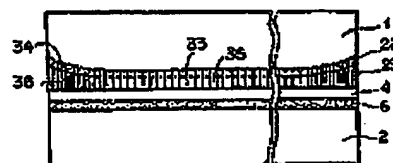
【図2】



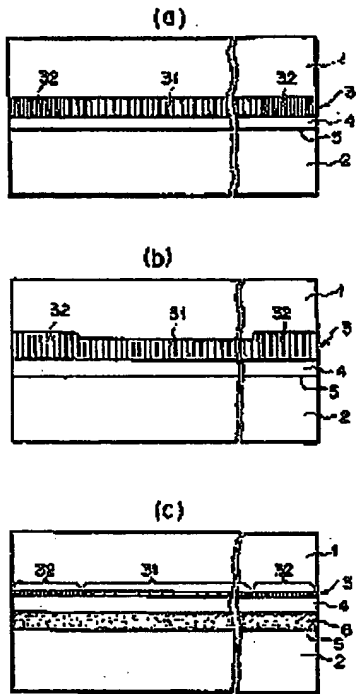
【図3】



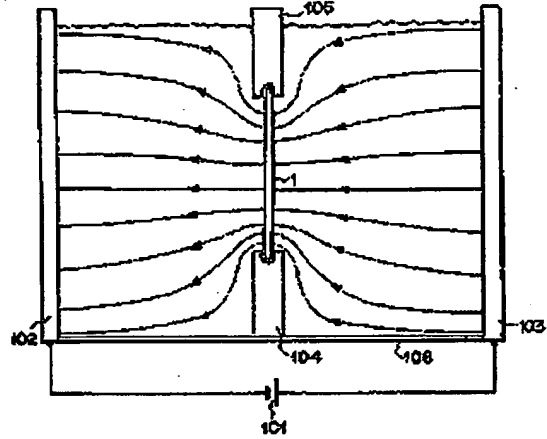
【図11】



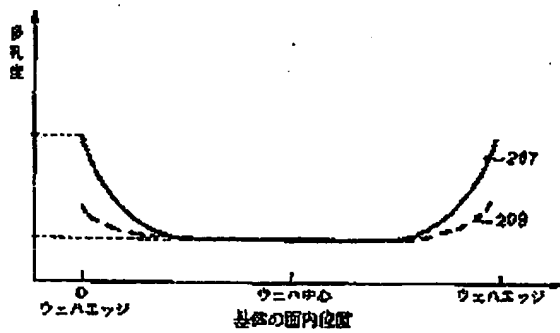
【図1】



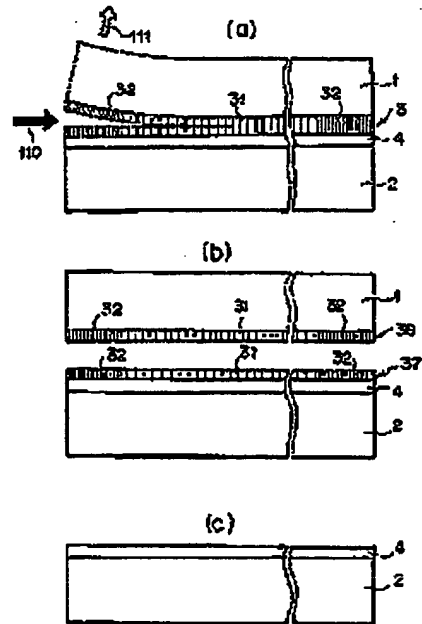
【図4】



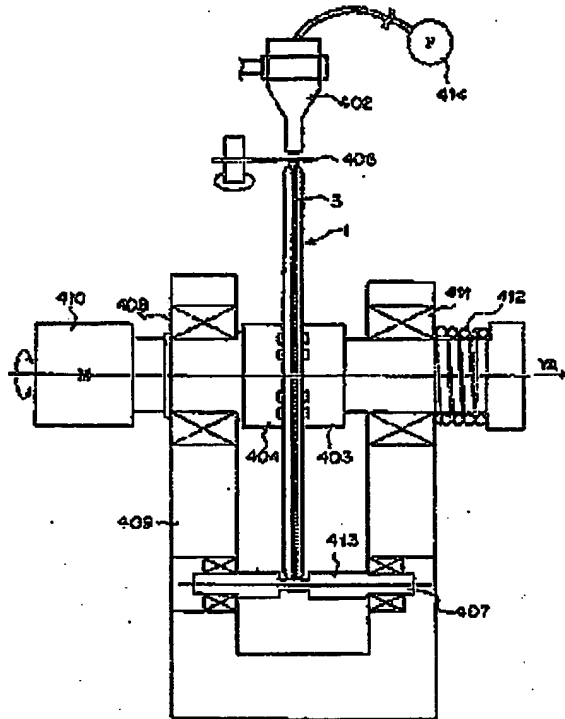
【図5】



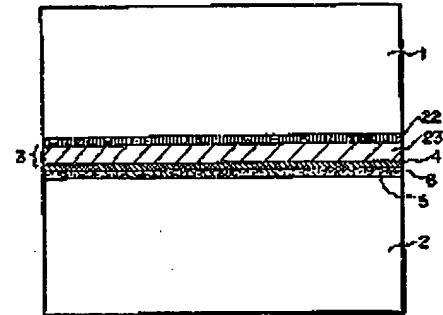
【図6】



【図7】

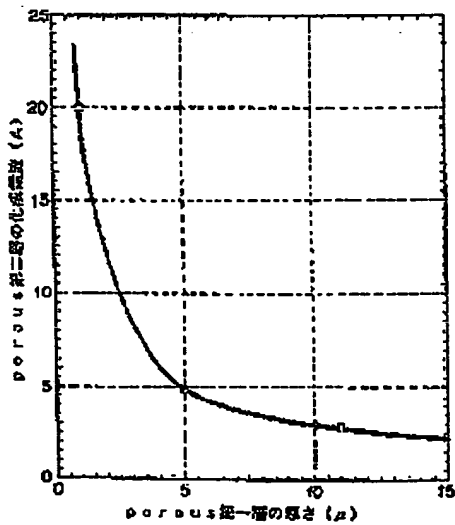


【図8】

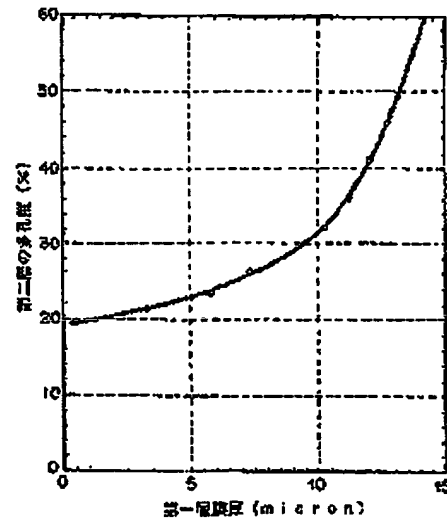


- 1: 第一の基体
- 2: 第二の基体
- 3: 分離層
- 4: 多孔質第1層
- 5: 貼り合わせ界面
- 6: 多孔質第2層
- 22: 多孔質第2層(高多孔度)
- 23: 多孔質第1層(低多孔度)

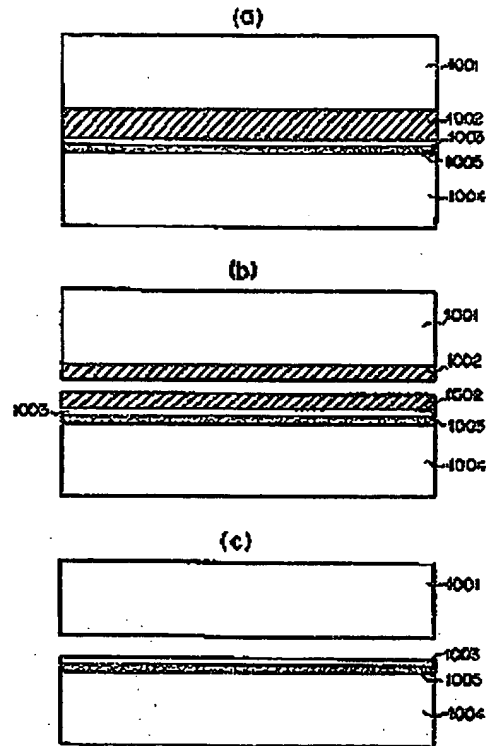
【図9】



【図10】



【図12】



## 【手続補正言】

【提出日】平成11年6月22日

## 【手続補正1】

【補正対象書類名】明細書

【補正対象項目名】特許請求の範囲

【補正方法】変更

【補正内容】

【特許請求の範囲】

【請求項1】 複合部材を、分離領域で複数の部材に分離する工程を含む複合部材の分離方法において、前記分離領域の機械的強度が前記複合部材の表面に沿った方向に不均一であり該分離領域の周辺部の機械的強度が局所的に弱いことを特徴とする分離方法。

【請求項2】 前記分離領域の機械的強度が貼り合わせ箇所よりも弱い請求項1に記載の分離方法。

【請求項3】 前記分離領域が陽極化成法によって形成された多孔質層である請求項1に記載の分離方法。

【請求項4】 前記複合部材が微陥円盤状であり、前記分離領域の機械的強度が該複合部材内の中央部で高く周辺部で低く、且つ円周方向に沿ってほぼ均一である請求項1に記載の分離方法。

【請求項5】 互いに多孔度の異なる部分を形成することによって前記分離領域の機械的強度を不均一にする請求項1に記載の分離方法。

【請求項6】 前記分離領域の多孔度を中央部よりも周辺部で高くする請求項1に記載の分離方法。

【請求項7】 前記分離領域に、互に厚さの異なる部分を形成することによって機械的強度を不均一にする請求項1に記載の分離方法。

【請求項8】 前記多孔質層の厚さを中央部よりも周辺部で厚くする請求項5に記載の分離方法。

【請求項9】 前記分離領域が機械的強度の異なる複数の層からなる請求項1に記載の分離方法。

【請求項10】 前記分離領域は多孔度が高い層と多孔度が低い層とを有する請求項1に記載の分離方法。

【請求項11】 前記多孔度が高い層の多孔度が中央部よりも周辺部でより高い請求項10に記載の分離方法。

【請求項12】 前記多孔度が低い層の厚さを中央部よりも周辺部で厚くし、前記多孔度が高い層の多孔度を中央部よりも周辺部で高くする請求項10に記載の分離方法。

【請求項13】 前記分離領域を形成するための陽極化成の電流密度を面内で変化させることにより前記多孔度が低い層の周辺部における厚さを基体の中央部より厚くすることを特徴とする請求項12に記載の分離方法。

【請求項14】 前記陽極化成される基体の近傍における電流密度を面内で変化させることにより前記多孔度が低い層の周辺部における厚さを基体の中央部より厚くすることを特徴とする請求項12に記載の分離方法。

体の面積よりも大きくすることによって、周辺部に流入する化成電流の面密度を中央部に流入する化成電流の面密度よりも大きくし、前記多孔度の低い層の周辺部の厚さを中央部より厚くし、その後形成する前記多孔度の高い層の周辺部の多孔度を中央部の多孔度より高くすることを特徴とする請求項13に記載の分離方法。

【請求項15】 前記陽極化成される基体近傍に、前記基体表面に流入するイオン電流分布を制御する電流ガイドを設けて、前記多孔度の低い層の厚さを面内で異ならしめることを特徴とする請求項13に記載の分離方法。

【請求項16】 前記分離領域は、イオン打ち込みにより形成された微小気泡を得ることのできる層である請求項1に記載の分離方法。

【請求項17】 前記分離領域の周辺部のイオン注入量を中央部より大きくする請求項16に記載の分離方法。

【請求項18】 流体を吹き付けることにより、前記分離領域に亀裂を生じさせることを特徴とする請求項1に記載の分離方法。

【請求項19】 前記流体を吹き付ける方法として、高圧の水流をノズルから吹き出すウォーター・ジェット法を用いる請求項18に記載の分離方法。

【請求項20】 前記複合部材の側面に、流体を受けて前記分離領域を押し広げる方向の力を生ずるような、凹型を形成する請求項18に記載の分離方法。

【請求項21】 前記複合部材は単結晶シリコン基板を部分的に多孔質化することによって多孔質単結晶シリコン層を形成し、該多孔質単結晶シリコン層上に非多孔質単結晶シリコン層をエピタキシャル成長することによって形成された基体を有することを特徴とする請求項18に記載の分離方法。

【請求項22】 前記複合部材は第一の基体と第二の基体が、絶縁層を介して貼り合わされたものであり、該絶縁層は前記第一の基体の非多孔質単結晶シリコン層の表面を酸化することによって形成されたものであることを特徴とする請求項1に記載の分離方法。

【請求項23】 前記分離領域として単結晶半導体から成る第一の基体の所定の深さにイオンを打ち込むことにより微小気泡を得ることのできるイオン打ち込み層を形成する工程、前記第一の基体と前記第二の基体とを、前記第一の基体のイオンを打ち込んだ面が内側に位置する複合部材が得られるようにして貼り合わせる工程、及び前記複合部材の側面に流体を吹き付けることにより、前記複合部材を分離する工程とを有することを特徴とする請求項1に記載の分離方法。

【請求項24】 前記複合部材の側面に、流体を受けてイオン打ち込み層を押し広げる方向の力を生ずるような、凹型を持たせる請求項1に記載の分離方法。

【請求項25】 前記イオン打ち込み層は、前記貼り合わせ箇所よりも機械的強度が弱い請求項23に記載の分離方法。

【請求項26】 前記周辺部の多孔度と、多孔度の極小値と、の差が5%以上である請求項1に記載の分離方法。

【請求項27】 前記周辺部の多孔度と、多孔度の極小値と、の差が10%以上である請求項1に記載の分離方法。

【請求項28】 前記周辺部の多孔度は、20%以上80%以下から選択される請求項1に記載の分離方法。

【請求項29】 前記周辺部の多孔度は、35%以上80%以下から選択される請求項1に記載の分離方法。

【請求項30】 前記中央部の多孔度は5%以上35%未満から選択される請求項1に記載の分離方法。

【請求項31】 前記中央部の多孔度は5%以上20%未満から選択される請求項1に記載の分離方法。

【請求項32】 前記分離領域は、前記周辺部の面積より機械的強度が高い部分の面積が大きい請求項1に記載の分離方法。

【請求項33】 前記分離領域は、機械的強度が高い部分が前記複合部材の中心からずれている請求項1に記載の分離方法。

【請求項34】 請求項1に記載の分離方法を用いた半導体基体の製造方法。

【請求項35】 第一の基体と第二の基体が互いに貼り合わされた複合部材を、貼り合わせ面とは異なる箇所に形成された分離領域で複数の部材に分離する工程を含む半導体基体の製造方法において、前記分離領域の機械的強度が該貼り合わせ面に沿った方向に不均一であり該分離領域の周辺部の機械的強度が局所的に弱いことを特徴とする半導体基体の製造方法。

【請求項36】 前記分離領域の機械的強度が前記貼り合わせ面よりも弱い請求項35に記載の半導体基体の製造方法。

【請求項37】 前記分離領域が陽極化成法によって形成された多孔質層である請求項35に記載の半導体基体の製造方法。

【請求項38】 前記複合部材が微陥円盤状であり、前記分離領域の機械的強度が該複合部材内の中央部で高く周辺部で低く、且つ円周方向に沿ってほぼ均一である請求項35に記載の半導体基体の製造方法。

【請求項39】 互いに多孔度の異なる部分を形成することによって前記分離領域の機械的強度を不均一にする請求項35に記載の半導体基体の製造方法。

【請求項40】 前記分離領域の多孔度を中央部よりも周辺部で高くする請求項35に記載の半導体基体の製造方法。

【請求項41】 前記分離領域に、互に厚さの異なる部分を形成することによって機械的強度を不均一にする請求項35に記載の半導体基体の製造方法。

【請求項42】 前記多孔質層の厚さを中央部よりも周

法。

【請求項43】 前記分能領域が機械的強度の異なる複数の層からなる請求項35に記載の半導体基体の製造方法。

【請求項44】 前記分能領域は多孔度が高い層と多孔度が低い層とを有する請求項35に記載の半導体基体の製造方法。

【請求項45】 前記多孔度が高い層の多孔度が中央部よりも周辺部でより高い請求項43に記載の半導体基体の製造方法。

【請求項46】 前記多孔度が低い層の厚さを中央部よりも周辺部で厚くし、前記多孔度が高い層の多孔度を中央部よりも周辺部で高くする請求項43に記載の半導体基体の製造方法。

【請求項47】 陽極化成の電流密度を面内で変化させることにより前記多孔度が低い層の周辺部における厚さを基体の中央部より厚くすることを特徴とする請求項46に記載の半導体基体の製造方法。

【請求項48】 陽極化成される前記第一の基体の近傍における陽極化成液中のイオン電流が流れる断面積を、前記第一の基体の面積よりも大きくすることによって、周辺部に流入する化成電流の面密度を中央部に流入する化成電流の面密度よりも大きくし、前記多孔度の低い層の周辺部の厚さを中央部より厚くし、これによりその後形成する前記多孔度の高い層の周辺部の多孔度を中央部の多孔度より高くすることを特徴とする請求項47に記載の半導体基体の製造方法。

【請求項49】 前記陽極化成される第一の基体近傍に、前記第一の基体表面に流入するイオン電流分布を制御する電流ガイドを設けて、前記多孔度の低い層の厚さを面内で異ならしめることを特徴とする請求項47に記載の半導体基体の製造方法。

【請求項50】 前記分能領域は、イオン打ち込みにより形成された微小気泡を得ることのできる層である請求項35に記載の半導体基体の製造方法。

【請求項51】 周辺部のイオン注入量を中央部より大きくする請求項50に記載の半導体基体の製造方法。

【請求項52】 前記分能領域付近に流体を吹き付けることにより、前記分能領域に亀裂を生じさせることを特徴とする請求項35に記載の半導体基体の製造方法。

【請求項53】 前記流体を吹き付ける方法として、高圧の水流をノズルから吹き出すウォーター・ジェット法を用いる請求項52に記載の半導体基体の製造方法。

【請求項54】 前記複合部材の側面に、流体を受けて分能領域を押し広げる方向の力を生ずるような、凹型を持たせる請求項52に記載の半導体基体の製造方法。

【請求項55】 前記第一の基体は、単結晶シリコン基板を部分的に多孔質化することによって多孔質単結晶シリコン層を形成し、該多孔質単結晶シリコン層上に非多

によって形成される請求項35に記載の半導体基体の製造方法。

【請求項56】 前記第一の基体と前記第二の基体は、絶縁層を介して貼り合わされ、該絶縁層は前記第一の基体の非多孔質単結晶シリコン層の表面を酸化することによって形成される請求項54に記載の半導体基体の製造方法。

【請求項57】 前記分能領域として単結晶半導体から成る前記第一の基体の所定の深さにイオンを打ち込むことにより、微小気泡層を得ることのできるイオン打ち込み層を形成する工程、前記第一の基体と前記第二の基体とを、前記第一の基体のイオンを打ち込んだ面が内側に位置する複合部材が得られるように、貼り合わせる工程、及び前記複合部材の側面に流体を吹き付けることにより、前記複合部材を分能する工程を有することを特徴とする請求項35に記載の半導体基体の製造方法。

【請求項58】 前記複合部材の側面に、流体を受けてイオン打ち込み層を押し広げる方向の力を生ずるような、凹型を持たせる請求項35に記載の半導体基体の製造方法。

【請求項59】 前記イオン打ち込み層は、前記貼り合わせ面よりも機械的強度が弱い請求項57に記載の半導体基体の製造方法。

【請求項60】 前記周辺部の多孔度と、多孔度の極小値と、の差が5%以上である請求項35に記載の半導体基体の製造方法。

【請求項61】 前記周辺部の多孔度と、多孔度の極小値と、の差が10%以上である請求項35に記載の半導体基体の製造方法。

【請求項62】 前記周辺部の多孔度は、20%以上80%以下から選択される請求項35に記載の半導体基体の製造方法。

【請求項63】 前記周辺部の多孔度は、35%以上80%以下から選択される請求項35に記載の半導体基体の製造方法。

【請求項64】 前記中央部の多孔度は5%以上35%未満から選択される請求項35に記載の半導体基体の製造方法。

【請求項65】 前記中央部の多孔度は5%以上20%未満から選択される請求項35に記載の半導体基体の製造方法。

【請求項66】 前記分能領域は、前記周辺部の面積よりも機械的強度が高い部分の面積が大きい請求項35に記載の半導体基体の製造方法。

【請求項67】 前記分能領域は、機械的強度が高い部分が前記複合部材の中心からずれている請求項35に記載の半導体基体の製造方法。

【請求項68】 内部に分能領域を有する複合部材において、前記分能領域の機械的強度が該複合部材の表面に



的強度が局所的に弱いことを特徴とする複合部材。

【請求項69】 請求項34乃至67のいずれかに記

載された半導体基体の製造方法により製造された半導体  
基体。

\* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

CLAIMS

---

[Claim(s)]

[Claim 1] The separation approach characterized by being uneven in the separation approach of a compound member including the process which divides a compound member into two or more members in an isolation region in the direction in which the mechanical strength of said isolation region met the front face of said compound member, and the mechanical strength of the periphery of this isolation region being locally weak.

[Claim 2] The separation approach according to claim 1 that the mechanical strength of said isolation region is weaker than a lamination part.

[Claim 3] The separation approach according to claim 1 that said isolation region is the porous layer formed by the anodization method.

[Claim 4] Said compound member is outline discoid, and the mechanical strength of said isolation region is highly low in the center section in this compound member at a periphery, and a circumferencial direction is met, and it is the almost uniform separation approach according to claim 1.

[Claim 5] The separation approach according to claim 1 which makes the mechanical strength of said isolation region an ununiformity by forming the part from which porosity differs mutually.

[Claim 6] The separation approach according to claim 1 which makes the porosity of said isolation region higher than a center section at a periphery.

[Claim 7] The separation approach according to claim 1 which makes a mechanical strength an ununiformity by forming in said isolation region the part from which thickness differs in \*\*.

[Claim 8] The separation approach according to claim 5 which makes thickness of said porous layer thicker than a center section at a periphery.

[Claim 9] The separation approach according to claim 1 that said isolation region consists of two or more layers from which a mechanical strength differs.

[Claim 10] Said isolation region is the separation approach according to claim 1 of having a layer with high porosity, and a layer with low porosity.

[Claim 11] The separation approach according to claim 10 at a periphery that the porosity of a layer with said high porosity is higher than a center section.

[Claim 12] The separation approach according to claim 10 that said porosity makes thickness of a low layer thicker than a center section at a periphery, and said porosity makes the porosity of a high layer higher than a center section by the periphery.

[Claim 13] The separation approach according to claim 12 characterized by said porosity making thickness in the periphery of a low layer thicker than the center section of the base by changing the current density of the anodization for forming said isolation region in a field.

[Claim 14] The cross section to which the ion current in anodization liquid [ / near said base by which anodization is carried out ] flows by making it larger than the area of said base It is made larger than the surface density of a current. the formation which flows into a periphery -- the formation which flows the surface density of a current into a center section -- The separation approach according to claim 13 which makes thickness of the periphery of a layer with said low porosity thicker than a center section, and is characterized by making higher than the porosity of a center section the porosity of the periphery of a layer with said high porosity which this forms after that.

[Claim 15] The separation approach according to claim 13 characterized by preparing the current guide which controls the ion current distribution which flows into said base front face near [ said ] the base by which anodization is carried out, and making the thickness of a layer with said low porosity differ in a field.

[Claim 16] Said isolation region is the separation approach according to claim 1 which is the layer which can obtain the very small air bubbles formed of ion implantation.

[Claim 17] The separation approach according to claim 16 which makes the ion injection rate of the periphery of said isolation region larger than a center section.

[Claim 18] The separation approach according to claim 1, characterized by making said isolation region produce a crack by spraying a fluid.

[Claim 19] The separation approach according to claim 18 using the water jet method which blows off a high-pressure stream from a nozzle as an approach of spraying said fluid.

[Claim 20] The separation approach according to claim 18 which forms in the side face of said compound member a concave which produces the force of the direction which extends an isolation region in response to a fluid.

[Claim 21] Said compound member is the separation approach according to claim 18 characterized by having the base which formed the porosity single-crystal-silicon layer and was formed by growing a nonvesicular single-crystal-silicon layer epitaxially on this porosity single-crystal-silicon layer by porosity-izing a single crystal silicon substrate partially.

[Claim 22] It is the separation approach according to claim 1 characterized by being formed when, as for said compound member, the first base and second base are stuck through an insulating layer and this insulating layer oxidizes the front face of the nonvesicular single-crystal-silicon layer of said first base.

[Claim 23] By driving ion into the predetermined depth of the first base which consists of a single crystal semiconductor as said isolation region. The process which forms the ion implantation layer which can obtain a very small air-bubbles layer (microcavity layer), and said the first base and second base so that the compound member to which the field which drove in the ion of said first base is located inside may be obtained. The separation approach according to claim 1 characterized by having the process which separates said compound member by spraying a fluid on the process to stick and the side face of said compound member.

[Claim 24] The separation approach according to claim 1 of giving a concave which produces the force of the direction which extends an ion implantation layer in response to a fluid on the side face of said compound member.

[Claim 25] Said ion implantation layer is the separation approach according to claim 23 that a mechanical strength is weaker than said lamination part.

[Claim 26] The separation approach according to claim 1 that the porosity of said periphery, the minimal value of porosity, and the difference of \*\* are 5% or more.

[Claim 27] The separation approach according to claim 1 that the porosity of said periphery, the minimal value of porosity, and the difference of \*\* are 10% or more.

[Claim 28] The porosity of said periphery is the separation approach according to claim 1 chosen from 80% or less 20% or more.

[Claim 29] The porosity of said periphery is the separation approach according to claim 1 chosen from 80% or less 35% or more.

[Claim 30] The porosity of said center section is the separation approach according to claim 1 chosen from less than 35% 5% or more.

[Claim 31] The porosity of said center section is the separation approach according to claim 1 chosen from less than 20% 5% or more.

[Claim 32] Said isolation region is the separation approach according to claim 1 that the area of a part with a mechanical strength higher than the area of said periphery is large.

[Claim 33] Said isolation region is the separation approach according to claim 1 that the part with a high mechanical strength has shifted from the core of said compound member.

[Claim 34] The manufacture approach of the semi-conductor base using the separation approach according to claim 1.

[Claim 35] The manufacture approach of the semi-conductor base characterized by being uneven in the manufacture approach of a semi-conductor base including the process which divides the compound member on which the first base and second base of each other were stuck into two or more members in the isolation region formed in a different part from a lamination side in the direction in which the mechanical strength of said isolation region met this lamination side, and the mechanical strength of the periphery of this isolation region being locally weak.

[Claim 36] The manufacture approach of a semi-conductor base according to claim 35 with the mechanical strength of said isolation region weaker than said lamination side.

[Claim 37] The manufacture approach of a semi-conductor base according to claim 35 that said isolation region is the porous layer formed by the anodization method.

[Claim 38] Said compound member is outline discoid, and the mechanical strength of said isolation region is highly low in the center section in this compound member at a periphery, and a circumferential direction is met, and it is the manufacture approach of an almost uniform semi-conductor base according to claim 35.

[Claim 39] The manufacture approach of the semi-conductor base according to claim 35 which makes the mechanical strength of said isolation region an ununiformity by forming the part from which porosity differs mutually.

[Claim 40] The manufacture approach of the semi-conductor base according to claim 35 which makes the porosity of said isolation region higher than a center section at a periphery.

[Claim 41] The manufacture approach of the semi-conductor base according to claim 35 which makes a mechanical strength an ununiformity by forming in said isolation region the part from which thickness differs in \*\*.

[Claim 42] The manufacture approach of the semi-conductor base according to claim 38 which makes thickness of said porous layer thicker than a center section at a periphery.

[Claim 43] The manufacture approach of a semi-conductor base according to claim 35 that said isolation region consists of two or more layers from which a mechanical strength differs.

[Claim 44] Said isolation region is the manufacture approach of a semi-conductor base according to claim 35 of having a layer with high porosity, and a layer with low porosity.

[Claim 45] The manufacture approach of the semi-conductor base according to claim 43 at a periphery with the porosity of a layer with said high porosity higher than a center section.

[Claim 46] The manufacture approach of a semi-conductor base according to claim 43 that said porosity makes thickness of a low layer thicker than a center section at a periphery, and said porosity makes the porosity of a high layer higher than a center section by the periphery.

[Claim 47] The manufacture approach of the semi-conductor base according to claim 46 characterized by said porosity making thickness in the periphery of a low layer thicker than the center section of the base by changing the current density of anodization in a field.

[Claim 48] The cross section to which the ion current in anodization liquid [ / near said first base by which anodization is carried out ] flows by making it larger than the area of said first base It is made larger than the surface density of a current. the formation which flows into a periphery -- the formation which flows the surface density of a current into a center section -- The manufacture approach of the semi-conductor base according to claim 47 which makes thickness of the periphery of a layer with said low porosity thicker than a center section, and is characterized by making higher than the porosity of a center section the porosity of the periphery of a layer with said high porosity which this forms after that.

[Claim 49] The manufacture approach of the semi-conductor base according to claim 47 characterized by preparing the current guide which controls the ion current distribution which flows into said first base front face near [ said ] the first base by which anodization is carried out, and making the thickness of a layer with said low porosity differ in a field.

[Claim 50] Said isolation region is the manufacture approach of the semi-conductor base according to claim 35 which is the layer which can obtain the very small air bubbles formed of ion implantation.

[Claim 51] The manufacture approach of the semi-conductor base according to claim 50 which makes the ion injection rate of a periphery larger than a center section.

[Claim 52] The manufacture approach of the semi-conductor base according to claim 35 characterized by making said isolation region produce a crack by spraying a fluid near [ said ] an isolation region.

[Claim 53] The manufacture approach of the semi-conductor base according to claim 52 using the water jet method which blows off a high-pressure stream from a nozzle as an approach of spraying said fluid.

[Claim 54] The manufacture approach of the semi-conductor base according to claim 52 which gives a concave which produces the force of the direction which extends an isolation region in response to a fluid on the side face of said compound member.

[Claim 55] Said first base is the manufacture approach of the semi-conductor base according to claim 35 which forms a porosity single-crystal-silicon layer and is formed by growing a nonvesicular single-crystal-silicon layer epitaxially on this porosity single-crystal-silicon layer by porosity-izing a single crystal silicon substrate partially.

[Claim 56] It is the manufacture approach of the semi-conductor base according to claim 54 which said the first base and said second base are stuck through an insulating layer, and is formed when this insulating layer oxidizes the front face of the nonvesicular single-crystal-silicon layer of said first base.

[Claim 57] By driving ion into the predetermined depth of the first base which consists of a single crystal semiconductor as said isolation region The process which forms the ion implantation layer which can obtain a very small air-bubbles layer, and said the first base and second base so that the compound member to which the field which drove in the ion of said first base is located inside may be obtained The manufacture approach of the semi-conductor base according to claim 35 characterized by having the process which separates said compound member by spraying a fluid on the process to stick and the side face of said compound member.

[Claim 58] The manufacture approach of the semi-conductor base according to claim 35 which gives a concave which produces the force of the direction which extends an ion implantation layer in response to a fluid on the side face of said compound member.

[Claim 59] Said ion implantation layer is the manufacture approach of a semi-conductor base according to claim 57 with a mechanical strength weaker than said lamination side.

[Claim 60] The manufacture approach of a semi-conductor base according to claim 35 that the porosity of said periphery, the minimal value of porosity, and the difference of \*\* are 5% or more.

[Claim 61] The manufacture approach of a semi-conductor base according to claim 35 that the porosity of said periphery, the minimal value of porosity, and the difference of \*\* are 10% or more.

[Claim 62] The porosity of said periphery is the manufacture approach of the semi-conductor base according to claim 35

chosen from 80% or less 20% or more.

[Claim 63] The porosity of said periphery is the manufacture approach of the semi-conductor base according to claim 35 chosen from 80% or less 35% or more.

[Claim 64] The porosity of said center section is the manufacture approach of the semi-conductor base according to claim 35 chosen from less than 35% 5% or more.

[Claim 65] The porosity of said center section is the manufacture approach of the semi-conductor base according to claim 35 chosen from less than 20% 5% or more.

[Claim 66] Said isolation region is the manufacture approach of a semi-conductor base according to claim 35 with a large area of a part with a mechanical strength higher than the area of said periphery.

[Claim 67] Said isolation region is the manufacture approach of a semi-conductor base according to claim 35 that the part with a high mechanical strength has shifted from the core of said compound member.

[Claim 68] The compound member characterized by being uneven in the direction where the mechanical strength of said isolation region met the interior on the front face of this compound member in the compound member which has an isolation region, and the mechanical strength of the periphery of this isolation region being locally weak.

---

[Translation done.]

\* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

DETAILED DESCRIPTION

---

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the manufacture approach of a semi-conductor base at the separation approach list which separates the compound member a compound mechanical strength has the weak brittle structured division inside about the manufacture approach of a semi-conductor base in a compound member and its separation approach list, and it. Especially this invention is suitable for the process of the substrate (SOI substrate) which has the SOI (Semiconductor on insulator) structure which is a kind of a semi-conductor base.

[0002]

[Description of the Prior Art] The device which adopted this SOI substrate has many dominance points which cannot be attained in the usual Si substrate. As this dominance point, the following are mentioned, for example.

- (1) Dielectric separation is easy and suitable for high integration.
- (2) Excel in radiation resistance.
- (3) Stray capacity is small and improvement in the speed of the working speed of a component is possible.
- (4) A well process is unnecessary.
- (5) A latch rise can be prevented.
- (6) Formation of the perfect depletion mold field-effect transistor by thin-film-izing is possible.

[0003] Since SOI structure has above various dominance points, research on the formation approach has been advanced for here dozens years.

[0004] as a SOI technique -- old -- a single crystal silicon-on-sapphire top -- Si -- CVD (chemistry gaseous layer growth) -- the SOS (silicon on sapphire) technique which is made to carry out hetero epitaxy growth and is formed by law is known. Although this SOS technique obtained evaluation temporary as a SOI technique which matured most, utilization is not progressing for the reasons of generating of a lot of crystal defects by the grid mismatching in the interface of Si layer and the silicon on sapphire of a substrate, mixing to Si layer of the aluminum which constitutes silicon on sapphire, the price of a substrate, the delay to large-area-izing, etc.

[0005] Subsequently to an SOS technique, the SIMOX (separation by ion implanted oxygen) technique appeared. Aiming at reduction of a crystal defect, reduction of a manufacturing cost, etc., various approaches have been tried about this SIMOX technique. On both sides of the approach and oxide film which pour in and embed oxygen ion as this approach at a substrate, and form an oxidizing zone, stick two wafers, and the wafer of 1 in all side is ground or etched. the approach of leaving a thin single crystal Si layer on an oxide film -- further After driving a hydrogen ion into the predetermined depth from the front face of Si substrate in which the oxide film was formed and sticking with the substrate of another side, it leaves a thin single crystal Si layer on this oxide film by heat-treatment etc., and the approach of exfoliating the stuck substrate (substrate of another side) etc. is mentioned.

[0006] A new SOI technique was indicated in the patent No. 2608351 official report or U.S. Pat. No. 5,371,037. This technique transfers a nonvesicular single crystal layer to the second substrate by removing a garbage for the first substrate in which the nonvesicular single crystal layer was formed on the single crystal semiconductor substrate with which the porous layer was formed, lamination and after that to the second substrate. This technique is excellent in respect of the ability to manufacture [ that the thickness homogeneity of a SOI layer is excellent, that the crystal defect consistency of a SOI layer can be reduced, that the surface surface smoothness of a SOI layer is good, that the manufacturing installation of an expensive special specification is unnecessary, ] the SOI substrate which has the SOI film of the range which is several 10nm - about 10 micrometers by the same manufacturing installation.

[0007] Furthermore, these people dissociated from the second substrate, without destroying the first substrate in JP, 7-302889, A, after sticking the first above-mentioned substrate and second above-mentioned substrate, after that, are making the front face of the first separated substrate smooth, and forming a porous layer again, and indicated the technique which reuses the first substrate. One example of the approach indicated by the official report concerned is explained using drawing 12 (a) - drawing 12 (c). After porosity-izing the surface layer of the 1st Si substrate 1001 and

forming a porous layer 1002, the single crystal Si layer 1003 is formed on it, and the principal plane of 2nd Si substrate 1004 with another this single crystal Si layer and first Si base is stuck through an insulating layer 1005 ( drawing 12 (a)). Then, a SOI substrate is formed by dividing the wafer stuck by the porous layer ( drawing 12 (b)), and removing alternatively the porosity Si layer exposed to the front face by the side of 2nd Si base ( drawing 12 (c)). The first Si substrate 1001 can remove and reuse the porous layer 1002 which remained.

[0008] Invention indicated by JP,7-302889,A is very useful when attaining low cost-ization of a semi-conductor substrate, since the substrate with which the structure of a porosity silicon layer dissociates and used the substrate for the production process of a semi-conductor substrate once using the brittle point compared with nonvesicular silicon can be again used for the production process of a semi-conductor substrate. Moreover, since the first substrate can be used for this technique without futility, it can reduce a manufacturing cost sharply and has the outstanding advantage that a production process is also simple.

[0009] As an approach of separating the first base (substrate) of the above, and the second base (substrate) Others [ approaches /, such as pressurization, hauling shear, wedge insertion, heat treatment, oxidation, wave-motion impression, and a wire cut, ], There is an approach which this invention persons spray the fluid proposed in the application number 047 or No. 327 for which it applied to the U.S. on an isolation region, and separate on Japanese Patent Application No. No. 75498 [ nine to ] and March 25, 1998. As this fluid, a gas and/or a liquid are used and the water jet using the liquid which uses especially water as a principal component etc. can use it preferably. On the occasion of separation, this approach enters equally the clearance between not only an operation but the first base and the second base with which water cuts a lamination side, and can put a comparatively uniform separation pressure on the whole separation side. Moreover, this approach cannot sprinkle particle like [ in the case of a gas ], but can flush it rather. The approach of separating by wedge insertion is excelled in these two points. When especially the mechanical strength of an isolation region is made brittler than a lamination part, by spraying the flow of a fluid on this, only a brittle part is fractured, destroyed or removed and the part with the other strong reinforcement has the big advantage that it can leave without being destroyed.

[0010]

[Problem(s) to be Solved by the Invention] However, if the reinforcement of an isolation region is strong when it is going to separate the stuck compound member using fluids, such as a water jet, and a fluid is sprayed a side face, especially near an isolation region side face a compound member, flow of a fluid may be unable to destroy or cut an isolation region easily. In such a case, although it can dissociate by heightening the pressure of a fluid, if a pressure is made high too much, as the crack advances inside from the side face of a lamination base, it may be divided for the pressure of the fluid with which both both [ one of the two or ] which were separated were poured into the isolation region. For this reason, the yield fall might occur in the separation process. Although one approach for avoiding this is weakening the mechanical strengths of all isolation regions further, and making it brittler structure, when it weakens too much, an isolation region breaks during the handling of the base of the heating process and washing process in the middle of a compound member creation process, and others, it may not result in lamination, or an isolation region may collapse, particle may occur and it may become a pollution source.

[0011] Moreover, since the same problem arises fundamentally also when it is going to dissociate by other approaches without using a fluid, the yield in a separation process may fall.

[0012] The purpose of this invention is to offer the compound member which can separate a compound member comparatively easily, and its separation approach, without damaging the separated base.

[0013] Another purpose of this invention is to offer the compound member which the mechanical strength of an isolation region could be strengthened comparatively, suppressed collapse which an isolation region does not mean, and suppressed generating of particle, and its separation approach.

[0014]

[Means for Solving the Problem] This invention can be attained by the manufacture approach of the semi-conductor base characterized by the uneven thing in the separation approach of a compound member including the process which divides a compound member into two or more members in an isolation region in the direction in which the mechanical strength of an isolation region met the front face of a compound member.

[0015] It is desirable that the mechanical strength of the compound member periphery of said isolation regions is especially weaker than a center section. Moreover, as for said isolation region, it is desirable to coincidence that a mechanical strength is weaker than said lamination part.

[0016] This isolation region can use the layer which can obtain the very small air bubbles formed of the porous layer formed by the anodization method, or ion implantation. When using semi-conductor bases, quartz wafers, etc., such as Si wafer, as the first base of the above, or the second base, although these have the orientation flat and the notch, since it is disc-like in general, said compound member which sticks these first bases and the second base of each other, and changes is also outline discoid. In such a case, the mechanical strength of said isolation region has the high heterogeneity to which it becomes low by the periphery in the core in this compound member, and the in general more uniform one is

divided into a circumferencial direction good. When a compound member is rectangular plate-like part material, the mechanical strength of the corner, one side, or the perimeter is weakened.

[0017] A mechanical strength can be made into an ununiformity by forming in said isolation region the part from which porosity differs mutually. Since a mechanical strength becomes weak so that porosity is enlarged, a mechanical strength is changed by changing porosity. The mechanical strength in the periphery can be weakened by more specifically making porosity higher than a center section at a periphery.

[0018] Said isolation region can make a mechanical strength an ununiformity also by changing the thickness. Since a mechanical strength becomes weak, a mechanical strength also changes by changing the thickness, so that thickness of said isolation region is thickened. Therefore, the porous layer of said isolation region can weaken the mechanical strength in the periphery also by making the thickness at a periphery larger than the center section of the base.

[0019] In order to obtain the compound member which was more suitable although separation does not take place at the process before the separation process of said compound member but it dissociates certainly at a separation process, it is more desirable to form said isolation region from two or more layers from which a mechanical strength differs. It is desirable that the porosity which adjoins a nonvesicular single crystal half conductor layer makes thickness of a layer with high porosity thinner than the thickness of a low layer into said isolation region which consists of two or more above-mentioned layers especially. There is not necessarily no need that the structure of each layer in it changes steeply in the interface, as for two or more above-mentioned layers. Though it is changing continuously by the interface of adjacent layers, it becomes easy to separate the reinforcement and structure of each class rather than reinforcement is uniform over the whole isolation region.

[0020] In said isolation region which consists of two or more layers from which said mechanical strength differs, it is more desirable that the porosity of a layer with said high porosity is more higher than near the center section of the base at a periphery.

[0021] When forming said isolation region which consists of a field of the shape of two or more layer where said mechanical strengths differ, the porosity which is the 2nd layer with said large porosity can be made at a periphery larger than the center section of the base by making at a periphery thickness which is the 1st layer with said small porosity larger than the center section of the base.

[0022] this invention persons were conducting the experiment which performs various reconstruction to anode plate degassing equipment that a good porous layer should be formed. It found out then that there was an Si wafer which has the field internal division cloth of porosity in two or more Si wafers which performed porosity-ized processing using the anode plate degassing equipment of a certain gestalt.

[0023] Moreover, it turned out that the sample in which the nonvesicular layer was formed on the porous layer is prepared, and there is a sample which can exfoliate more easily from what has comparatively high porosity even if the porosity of a porous layer is comparatively low, when the experiment which exfoliates the nonvesicular layer is conducted.

[0024] If it sets to the porous layer to which porosity has field internal division cloth like the operation gestalt mentioned later based on the two above-mentioned knowledge and the layer of the degree of Kota hole fractures or collapses comparatively, the layer of comparatively low porosity will also be fractured easily and it will not receive effect in the absolute value of porosity so much.

[0025] That is, when there is a layer of the degree of Kota hole relatively [ periphery / which is easy to make separation start / of a member ], irrespective of the absolute value of the porosity, it finds out that separation becomes easy and came to make this invention.

[0026]

[Embodiment of the Invention] Drawing 1 (a) - drawing 1 (c) are the sectional views of the compound member by the gestalt of 1 operation of this invention.

[0027] As a compound member is shown in drawing 1 (a), the first base 1 and second base 2 stick mutually, are set, and are formed, and the isolation region 3 is formed in the interior. Here, the first base 1 has a lamination interface in the place which is contacted on the front face of the second base 2, is stuck, and shows the layer 4 formed on the isolation region 3 to a sign 5.

[0028] The mechanical strength has the comparatively strong part 31 and the weak part 32, and an isolation region 3 has the part 32 with a weak mechanical strength in the periphery (periphery of an isolation region) of a compound member.

[0029] Since the weak part 32 of a mechanical strength exists in the periphery of a compound member relatively when separating this compound member, a crack or collapse arises into this part 32 previously, and it becomes easy to separate a compound member.

[0030] For explaining in more detail, drawing 1 (a) formed the part 32 which consists of a porous body with high porosity in the periphery of the isolation region 3 where thickness is uniform, and has formed the weak part 32 of a mechanical strength locally at the periphery by forming the part 31 which consists of a porous body with low porosity in the center section. Drawing 2 (a) shows the location of the strong part 31 of the mechanical strength at the time of seeing



this compound member from a top face, and the weak part 32. A sign 7 is an orientation flat prepared if needed.

[0031] Moreover, the weak part 32 of a mechanical strength may be a part of periphery section, as shown in drawing 2 B instead of all the peripheries of a compound member. It is desirable to make area of the strong part 31 of a mechanical strength sufficiently larger than the area of the weak part 32.

[0032] Drawing 1 (b) is making into an ununiformity thickness of the isolation region 3 which consists of a porous body of uniform porosity, and forms the weak part 32 of a mechanical strength in a periphery. As the flat surface of an isolation region 3 is shown in drawing 2 B also in this case, it may be locally formed in a part of periphery section.

[0033] Drawing 1 (c) forms the weak part 32 of a mechanical strength by forming a part with many ion injection rates in a periphery by ion implantation. Also in this case, as shown in drawing 2 (b), an ion injection rate can be locally made [ many ] and the weak part 32 of a mechanical strength can also be formed in a part of periphery section. Since very small air bubbles will arise if a hydrogen ion and rare gas ion are driven in and predetermined heat treatment is performed, the part by which the ion implantation was carried out to high concentration can also be made into a porous body with high porosity.

[0034] Both, the weak part 32 of a mechanical strength is higher than other parts, is thickening and may form the porosity and thickness of a porous body locally. Moreover, ion may be locally driven into the isolation region which consists of a porous body, the porous body of the part by which the ion implantation was carried out may be made brittle, and a mechanical strength may be weakened.

[0035] That is, it is also desirable to combine suitably the description part of a configuration of to have been shown in drawing 1 (a) - drawing 1 (c).

[0036] As the first base 1 used for this invention, tabular semi-conductor wafers other than Si wafer, such as germanium, SiGe, SiC, GaAs, GaAlAs, and InP, GaN, are used preferably.

[0037] As the second base 2, you may be insulating bases, such as quartz glass and a resin sheet, and metallicity bases, such as stainless steel, besides the same semi-conductor wafer as the first base 1.

[0038] The monolayer or two or more layers which consist of an ingredient chosen from the same semiconductor material as the ingredient of the first base as a nonvesicular layer are used preferably. When separating composite material and producing a SOI substrate, it is desirable that it is a single crystal half conductor layer.

[0039] What was formed with different ingredients from a layer 4, such as an insulator or a conductor, as a layer 6 shown in drawing 1 (c) is used preferably.

[0040] And when sticking the first and the second base, it is desirable to also make an insulating layer and the layer of adhesives intervene in between.

[0041] Drawing 3 (a) and drawing 3 (b) are graphs which show relatively distribution of the mechanical strength within the field of a compound member.

[0042] The part from a certain location LE 2 which a mechanical strength increases a continuous line 107 from the left periphery edge LE 1 of a compound member gradually toward the right periphery edge RE1 of a compound member to the center O toward Center O, and includes Center O to a location RE2 is the gestalt which a mechanical strength is the strongest and is fixed.

[0043] An alternate long and short dash line 108 is a gestalt in which the mechanical strength has changed intermittently between the periphery section (part from [ from the periphery edge LE 1 to a location LE 2 ] the periphery edge RE1 to a location RE2), and a center section (from a location LE 2 to a location RE2).

[0044] A broken line 109 is a gestalt which the mechanical strength is increasing from the periphery edges LE1 and RE1 continuously towards Center O, and, as for a mechanical strength, takes maximum in the Center O.

[0045] In this invention, it is desirable that the mechanical strength in the part from the location of the method of the inside of 5mm to the periphery edge of an isolation region weakens locally rather than the mechanical strength in a center section toward a center from the periphery edge of a compound member. If it is made to correspond to drawing 3 (a), it is desirable to form an isolation region as a film so that the location of the method of the inside of 5mm may consist of a periphery edge of a compound member toward a center between LE1 and LE2 and/or between RE2 and RE1.

[0046] Furthermore, when separating the compound member of the diameter of macrostomia from the periphery edge toward the center, it may be unable to dissociate so that the center section of the compound member may wish. In this case, it is good to form the weak part of a mechanical strength in the center locally.

[0047] Drawing 3 (b) shows an example of such a gestalt, and the high part of a mechanical strength is the doughnut-like part M between a periphery and a center.

[0048] As an isolation region, when using a porous layer, it is good for a mechanical strength to make the porosity of a weak periphery 35% or more more preferably 20% or more, and to make the upper limit of porosity 80% or less. Although the porosity of the center section where a mechanical strength is strong should be just lower than a periphery, it is good to choose desirably, so that it may become it is more desirable and lower than 5% or more of less than 20% of within the limits to a periphery less than 35% 5% or more.

[0049] If there is 10% or more of differences of porosity more preferably 5% or more, the difference of sufficient mechanical strength to divide a compound member into a periphery and a center section easily will be acquired.

[0050] Moreover, what is necessary is just to make the porosity of the part in which this part M, i.e., a mechanical strength, has the maximal value in making an isolation region from a porous body, since it becomes a part with the part strong [ a mechanical strength ] which shows with Sign M in the case of drawing 3 (b) more preferably as low as less than 20% 5% or more less than 35% 5% or more as well as the center section of drawing 3 (a).

[0051] The porosity of the center O in drawing 3 (b) is good to choose from 20% - 80% of range suitably that what is necessary is just more highly than Part M, so that the relation may be filled.

[0052] Porosity [ of a porous body ] P (%) expresses the rate of the volume which a hole occupies in the volume of the appearance of a porous body here. This porosity is expressed with the following formula using the consistency m of a porous body and the consistency M of a nonvesicular object which were formed on said 1st base.

[0053]

$$P = \{(M-m)/M\} \times 100 (\%) (1)$$

Here, weight G of the appearance of the porous-layer object containing a hole is \*(ed) by the volume V of the appearance of the porous body containing a hole with the consistency m of a porous body.  $m=G/V$  (2)

It comes out. In order to ask for the porosity P of the porous layer of the base which actually has layer structure only whose depth d by the side of a front face is a porous body, it can ask from a degree type using the weight B of the base after removing completely the weight a and the porous layer of said base after forming the weight A and the porous layer of a base before forming a porous layer.

[0054]

$$P = \{(A-a)/(A-B)\} \times 100 (3)$$

Next, the production approach of a compound member is described.

[0055] First, the first base 1 like Si wafer is prepared, and an isolation region 3 is formed in the part of the predetermined depth from the front face or a front face. There is the approach of forming in the part of the predetermined depth the ion implantation layer from which impregnation ion concentration serves as max from the front face of the first base 1 by carrying out the ion implantation of the different ion from the configuration element of a base like the approach and/or hydrogen ion which porosity-ize the front face of the first base 1 by anodization etc., or rare gas ion as a method of forming an isolation region. By controlling the conditions of anodization, and the conditions of ion implantation by the below-mentioned procedure, the weak part of a mechanical strength is made to a periphery.

[0056] Next, the nonvesicular layer 4 is formed on an isolation region 3 if needed, and it sticks on the 2nd base. In using ion implantation, the surface of the first base turns into the nonvesicular layer 4 as it is. In using porosity-ization, it forms a layer 4 by sputtering or CVD on the front face of the first porosity-ized base 1.

[0057] And the nonvesicular layer 4 is stuck on the 2nd base like Si wafer through an insulating layer 6 direct or if needed. In this way, a compound member is done.

[0058] One approach with being such for forming the weak porous layer of a mechanical strength locally is changing the current density of anodization in a field. the formation which flows into the periphery of a semi-conductor base -- by making current density high in the periphery of a base, it is thicker than the center section of the base, and the thickness and/or the porosity in a periphery of a base of said porous layer can be made high. In order to realize the above current density distribution, it is making the cross section to which the ion current in anodization liquid [ / near the base degassed ] flows in the case of anodization larger than the area of the base to degas. the formation which flows into a base periphery by this -- the formation which flows the surface density of a current in the center of a base -- what is necessary is just to make it larger than the surface density of a current What is necessary is to enlarge and for a base just to receive the ion current of the cross section larger than the area of a base from the base which degases specifically used  
\*\*\*\*\*

[0059] Drawing 4 shows notionally the equipment used for anodization. As for the DC power supply for anodization in 101, and 102, in drawing 4 , a cathode electrode and 103 are anode electrodes. 104,105 is an insulating supporter holding the processed base 1, and carries out the engagement of the base 1 in a crevice. 106 is an insulating layer pars basilaris ossis occipitalis.

[0060] here -- the area of an electrode 102,103 -- 1.2 time [ of the area of a base 1 ] - they are 1.3 times to about 2.0 times more preferably 3.0 times.

[0061] If it is made this appearance, in case the ion which has flowed from an outside [ edge / of a base / periphery ] will be brought together in a base, it flows in mostly by the periphery of a base, and it is large in the thickness of the porous layer of that part, and porosity can be made high.

[0062] Furthermore, it is possible to perform two or more steps of anodization, to make thickness of the periphery of the 1st porous layer thicker than a center section, and to make higher than the porosity of a center section the porosity of the periphery of the 2nd porous layer which this forms after that.

[0063] When distribution of such an inrush current needs to be further controlled to a precision, the current guide which

controls the ion current distribution which flows into a base front face near the base to degas can be prepared, and distribution of the thickness of a layer with said small porosity can be controlled by controlling ion current distribution. [0064] In using the layer which can obtain the very small air bubbles (microcavity) formed of said ion implantation as said isolation region, by making the consistency of ion implantation high, the magnitude and the consistency of the above-mentioned very small air bubbles, thickness over which very small air bubbles are distributed can be enlarged, and, thereby, it can make the mechanical strength of this field small.

[0065] Then, it is possible by making the ion injection rate of a base periphery larger than a base center section to raise the very small air-bubbles consistency per unit volume of a base periphery, and to make porosity higher than a base center section.

[0066] Drawing 5 is a graph which shows the field internal division cloth about the diameter direction of the porosity of the porosity acquired by the approach as shown in drawing 4.

[0067] Since a mechanical strength becomes weak so that porosity becomes high, compared with the continuous line 107 of drawing 3 (a), the continuous line 207 and dotted line 209 of this drawing 5 are the pattern of vertical reverse from this graph.

[0068] If the ratio of the area of an electrode 102,103 to the area of a base is large enough, it will become like a continuous line 207, and when the ratio of the area of an electrode to the area of a base is small, there is an inclination which becomes like a broken line 209. In this way, the porous body of the degree of Kota hole can be formed in a periphery.

[0069] The technique of on the other hand making the porous layer of mechanical-strength distribution as shown in the alternate long and short dash line 11 of drawing 1 (a) and drawing 3 (a) is described. The 1st approach is as follows. The photoresist pattern used as the mask of an ion notes necessity is prepared only in the periphery section of a base 1, and boron ion is injected into a center section. Anodization using the electrode of the almost same area is given with a base to the base with which the boron ion concentration of the periphery section became low locally, and the periphery section makes the porous layer of low porosity [ center section ] from the degree of Kota hole.

[0070] The 2nd approach is as follows. Except for the periphery section of a base, a center section is covered with anodization-proof masks, such as a wax, general anodization is performed under the conditions of high current density, and the periphery section is porosity-ized.

[0071] Next, the mask of the periphery section is carried out, general anodization is performed under the conditions of a low current consistency, and a center section is porosity-ized.

[0072] The 3rd approach also has the approach only the periphery section raises porosity by ion implantation, after forming a uniform porous layer by general anodization. If ion injection rate distribution is controlled, a porous layer with intensity distribution as shown in drawing 3 (a) and drawing 3 (b) can be formed with a sufficient controllability.

[0073] However, probably, in respect of a manufacturing cost, the approach shown in drawing 4 will be more advantageous than these approaches.

[0074] Next, the production approach of the compound member shown in drawing 1 (c) is described more concretely.

[0075] A base like Si wafer is oxidized and an insulator layer 6 is formed. The ion implantation of hydrogen or the rare gas ion is carried out to the whole base surface with predetermined acceleration voltage. The center section except the periphery section is covered with a photoresist mask pattern, and ion is driven in with the again same acceleration voltage as the periphery section. In this way, the isolation region 3 with the weak part 32 of a mechanical strength can be formed.

[0076] A mask pattern is removed and an insulator layer 6 is stuck on the second base 2. A mechanical strength should just set heteroatom concentration of a weak part to  $10^{20}\text{cm}^{-3}$ - $10^{23}\text{cm}^{-3}$ , using a dose [ in / for the dose in the 1st ion implantation / the 2nd ion implantation ] as  $10^{15}\text{cm}^{-2}$ - $10^{17}\text{cm}^{-2}$ , respectively.

[0077] Next, the separation approach of the compound member used for this invention is explained. As shown in drawing 6 (a), a compound member is divided into explaining the gestalt which separates the compound member shown in drawing 1 (a) as an example using the internal stress generated by heat treatment etc., and external force. Among isolation regions 3, since a periphery 32 has a locally weak mechanical strength, this collapses first or a crack produces it first here. Drawing 6 (a) shows signs that apply the force 111 which inserts a wedge 110 and pulls apart the periphery of the first base 1 from the second base 2, and it dissociates.

[0078] And a compound member is divided into two as shown in drawing 6 (b). When the residual layer 37 of the isolation region 3 which remains on the nonvesicular layer 4 is comparatively thick, polish and etching remove a residual layer. And it heat-treats in a hydrogen ambient atmosphere if needed (hydrogen annealing). In this way, the base 2 equipped with the layer 4 which has a smooth front face as shown in drawing 6 (c) is obtained.

[0079] In the case of the application of a solar battery etc., it is not necessary to remove a residual layer.

[0080] As the separation approach of said usable compound member, to this invention Pressurization, hauling which are indicated by JP,7-302889,A, Various approaches, such as shear, wedge insertion, heat treatment, wave-motion impression, and a wire cut, and said the first base and second base which were stuck which were proposed by Japanese.

Patent Application No. No. 75498 [ nine to ] by spraying a fluid near the side face of said isolation region The approach of dividing into two or more members in a different isolation region from a lamination interface is usable.

[0081] In order to dissociate in this invention, the flow of the fluid to be used is realizable by injecting the pressurized fluid from a thin nozzle. as the approach for making flow to inject into a high speed and a high-pressure narrow beam more -- "a water jet" -- a fluid jet process which is introduced to the 4th page per volume [ 1st ] No. etc. can be used. Fluid jet usable to this invention is 100 pressurized by high pressure pumping - 3000 kgf/cm<sup>2</sup>. By injecting a high-pressure liquid from a nozzle with the thin diameter of about 0.1-0.5mm, cutting (however, an abrasive material is added to water at the time of a hard ingredient) of the ceramics, a metal, concrete, resin, rubber, wood, etc., processing, removal of a surface paint film, washing on the front face of a member, etc. can be performed. In how to use the conventional water jet, it was the main effectiveness to remove some ingredients as mentioned above. That is, carrying out water jet cutting only in that for a principal piece, and removing \*\* and removal of a paint film, and washing on the front face of a member were removing an unnecessary part.

[0082] As the formation approach of the flow of the fluid of this invention, when using a water jet, it is possible by injecting a water jet on the side face of said isolation region to separate a compound member. In this case, said isolation region side face is first exposed on the side face of a lamination base, and a direct water jet is injected on there and the outskirts of it. Then, each base does not receive damage, but only the isolation region where mechanical strength is brittle is removed by the water jet, and the base of two sheets is separated. Moreover, said isolation region side face is not exposed beforehand by a certain reason, and even when the part is covered by film like an oxide film, after removing a wrap layer for an isolation region first by the water jet, it can dissociate by the water jet.

[0083] Moreover, although it is the effectiveness which was not used in the conventional water jet, by injecting jet to the crevice of the side face of a compound member, said isolation region where structure is brittle can be extended, it can destroy, and a lamination wafer can also be separated. In this case, it is possible to dissociate without giving a damage on the surface of separation, without using abrasives, even if the cutting waste of an isolation region is hardly generated and an isolation region cannot remove with the jet itself as a material.

[0084] Thus, this effectiveness can also be considered to be the effectiveness of a kind of same wedge as what was shown in drawing 6 (a) by the fluid instead of effectiveness, such as cutting and polish. Therefore, by a crevice's having this effectiveness in the side face of a lamination base, and injecting jet, when the force is applied in the direction which lengthens and removes an isolation region, effectiveness can be expected very much. It is more desirable for the configuration of the side face of a compound member to be not a convex type but a concave, if it is fully going to demonstrate this effectiveness.

[0085] Drawing 7 is the outline perspective view showing an example of the water jet equipment used for the manufacture approach of the semi-conductor base used for this invention. In drawing 7, a sign 1 is the compound member which carried out the lamination unification of the two Si wafers, and an isolation region 3 exists in the interior. 403,404 is the holder which adsorbs / fixes the compound member 1 by the vacuum chuck, and exists on the same revolving shaft mutually. Furthermore, a holder 404 can be rotated at the speed of arbitration by connecting with susceptor 409 through bearing 408, and the speed-control motor 410 linking directly and being connected in the rear. Moreover, the holder 403 was connected with susceptor 409 through bearing 411, and the force is applied in the direction YA in which a holder 403 separates from the compound member 1 by minding a compression spring 412 between susceptors 409 in the rear.

[0086] First, it sets so that the compound member 1 may be learned from a gage pin 413, and it is made to adsorb/hold at a holder 404. if a holder 404 is about the compound member 1 at a gage pin 413 -- \*\*\*\* -- it is things and compound member 1 center section can be held. Next, the compound member 1 learns it from bearing 411, and advances it leftward until it adsorbs / holds a holder 403. As for a holder 403, at this time, the force takes rightward by the compression spring 412. As for the appearance which a holder 403 does not separate from the compound member 1 by the force by the compression spring 412, the force in which a compression spring 412 returns, and the force in which a holder 403 attracts the compound member 1, balance is maintained at this time.

[0087] Next, it continues taking out during 1 scheduled time until it sends water into the water jet nozzle 402 from the water jet pump 414 and the water to spout is stabilized. If water is stabilized, the water (following water jet water) which opened the shutter 406 and blew off from the water jet nozzle 402 on the side face of the compound member 1 will be hit. At this time, the compound member 1 and a holder 403 are rotated by rotating a holder 404. In the side face of the compound member 1, water jet water is hitting near the core of the thickness, it extends the compound member 1 from the periphery section to two bodies toward a core, destroys a comparatively weak isolation region within the compound member 1, and, finally divides it into two bodies.

[0088] Like, after [ which was mentioned above at this time ] dissociating since the force is working rightward while water jet water is equally poured on the compound member 1 and a holder 403 holds the compound member 1, it is the device in which compound member 1 separated comrades do not slide.

[0089] Moreover, a liquid with the operation which does not use water but etches alternatively the isolation region of

alkali and others, such as acids, such as organic solvents, such as alcohol, and fluoric acid, a nitric acid, or a potassium hydroxide, as a fluid to be used etc. is usable. Furthermore, gases, such as air, nitrogen gas, carbon dioxide gas, and rare gas, may be used as a fluid. Gas and the plasma which have an etching operation to an isolation region can also be used. As for the water to be used, for the separation approach of the compound member introduced into the production process of a semi-conductor base, it is desirable to use water with the high purity of the pure water from which an impurity metal, particle, etc. were removed as much as possible, ultrapure water, etc. Moreover, if it washes after separation even if it uses fluid jet other than pure water, since it is a perfect low-temperature process, an impurity and particle can also be removed enough.

[0090] When using the approach of spraying such a fluid, it is desirable to give the configuration where it cratered in a concave which produces the force of the direction which extends an isolation region in response to liquid flow near the isolation region of said compound member. When it is going to separate the compound member with which the base of two sheets sticks and it comes to unite it across an isolation region in an isolation region, such structure can be easily realized by beveling the edge of each base.

[0091] When applying separating power to the isolation region currently beforehand formed in the compound member the flow of a fluid like a water jet, or by using the various approaches of pressurization, hauling, shear, wedge insertion, heat treatment, wave-motion impression, a wire cut, and others and separating into two, separation advances by [ of an isolation region ] destroying a brittle part mechanically. Also when the flow of a fluid is injected near an isolation region, the flow of a fluid removes or destroys the isolation region where a mechanical strength is brittle. And since the other part which is not brittle remains without being destroyed an isolation region being removed fundamentally [ in the case of a fluid ], there is an advantage that it can dissociate without damaging the part used after separation as a result. However, in the case of [ neither of ] the approaches, an isolation region may be unable to be destroyed if the reinforcement of an isolation region is not weak enough. For example, an isolation region may be unable to be destroyed or removed by the flow of the fluid of a predetermined pressure.

[0092] In order to solve this, when the pressure of a fluid is heightened, it is destroyed to the other part but not only an isolation region, for example, in separation of a lamination base, the tabular first or the second base may break. If the pressure of a fluid is lowered in order to prevent this, the dilemma that separation is impossible will arise.

[0093] It is necessary to stuff a solid wedge into the isolation region of the part formed in the periphery of a near [ the front face of the isolation region formed into the compound member at the initial stage of separation (for example, a disc-like lamination base) ] by the separation approach of above most. Thus, it is necessary to advance separation from a front face in many cases. However, the part near a front face has the problem that the area which applies separating power is small while separation does not advance, and the area consistency of the force must be made high. Although this can apply separating power to the separated field, it is because separating power cannot be applied to the field which has not been separated yet. In the phase in which separation advanced, since the area which can apply separating power increases and the surface density becomes low even if it makes it easy to enlarge separating power applied to a separation side, and to separate, it becomes easy to prevent breakage (crack etc.) of the base accompanying separation.

[0094] It is generated [ un-arranging / that an isolation region is destroyed /, and ], before thickening thickness of a porous layer which raises the porosity of the porous layer of an isolation region, or reaching a separation process in the middle of the formation process of said compound member in the early stages of separation by increasing the amount of formation of very small air bubbles by increasing the amount of ion implantation etc. if reinforcement becomes weak too much, although what is necessary is just to weaken mechanical strength in order to make separation easy.

[0095] It became clear that this invention persons changed the mechanical strength of an isolation region in the direction parallel to a lamination side, and should just weaken the mechanical strength of the part near the lamination base front face of said isolation region, for example, a periphery, compared with a base center section especially in order to avoid such un-arranging as a result of wholeheartedly research.

[0096] In the phase where the area of the field separated by the initial stage of separation cannot enlarge separating power small, the mechanical strength of an isolation region is weakened and separation is made to advance by the small force. This is possible by making small the mechanical strength of the isolation region near the periphery of a base. In the center section of the base, the mechanical strength of an isolation region is made higher than a periphery, and peeling in the middle of a process is prevented.

[0097] In this way, since the area which separation put in the center section and was separated at this time is large even if it sets, even if it makes surface density of separating power small, the whole separating power becomes large and can advance separation. Such effectiveness has the most desirable approach of injecting the flow of the above-mentioned fluid to an isolation region, in order to prevent breakage of a base, applying separating power to homogeneity comparatively in the whole field separated although it is not based on the separation approach but is demonstrated.

[0098] In order to make large the condition range for being stabilized and performing separation and to ensure separation without breakage of a base, the structure where an isolation region 3 consists of the field (22 23) of the shape of two or more layer where mechanical strengths differ like drawing 8 is desirable. In such a case, making the mechanical strength



in a periphery small compared with the center section of the base can be realized comparatively easily. the case where the isolation region has a laminated structure of the layer 23 (this is called the porous layer first pass for convenience.) with small porosity, and the large layer 22 (this is called for convenience the second layer of a porous layer.) -- the layer 23 with small porosity -- first -- an anodization method -- forming -- after an appropriate time -- formation -- what is necessary is to enlarge a current and just to form the layer 22 with large porosity by the anodization method similarly [0099] As for the porosity of 22, according to the place which this invention persons studied wholeheartedly, it turned out that it was not decided only by the magnitude of a current and is dependent also on the thickness and the porosity of the above-mentioned porous layer first pass 23 the second layer of the above-mentioned porous layer. the above-mentioned porous layer second -- formation of layer 22 -- even if it sets up a current equally, when the thickness of the above-mentioned porous layer first pass 23 is thick or porosity is low, there is an inclination for the porosity of 22 to become high the second layer of the above-mentioned porous layer. for this reason -- if thickness of the above-mentioned porous layer first pass 23 is made thin, for example, for keeping the porosity of 22 high the second layer of the above-mentioned porous layer -- a porous layer second -- formation of layer 22 -- it is necessary to make a current higher It is drawing 9 which showed this relation.

[0100] if -- formation of the second layer of a porous layer -- if a current is kept constant, and the thickness of the porous layer first pass changes, the porosity of the second layer of a porous layer will be influenced. Drawing 10 showed this relation. According to drawing 10, it is the related Fig. of the porosity (%) of the second layer to first pass thickness (micron), and after forming the porous layer first pass, it is clear to affect the porosity whose property of the porous layer first pass is the second layer of a porous layer rather than to be able to form the second layer of a porous layer independently of this. The detailed mechanism of such a phenomenon cannot be solved completely. however, it mentions later -- as -- formation of Porosity Si -- formation -- F- in liquid ion needs -- having -- \*\*\*\* -- the hole formation section at the tip of a hole -- F- if ion is consumed -- the hole from the front-face side of Porosity Si -- inside -- passing -- new F-Ion needs to be conveyed and it needs to be supplied at the tip of a hole.

[0101] such a hole -- inner F- It is thought that it depends for the electric field of ion or the effectual mobility of transportation by diffusion on the hole size of the first pass or the die length of a hole, i.e., the thickness of the first pass. That is, the porous layer first pass itself formed of anodization restricts transportation of ion required for porous layer formation of the point.

[0102] Therefore, F which needs the formed porous layer first pass for formation of the porous layer of the point - It works as an effectual mobility limit layer of ion transport. formation -- if a current is fixed, formation advances, without porosity seldom changing to considerable thickness. This is F at a fixed current. - Although the hole of a certain size decided by consumption of ion and balance of supply is formed, when a current is increased on the way, it is F by existence of a porous layer [ finishing / formation / already ]. - It thinks for consumption of ion and the balance of supply to change and for the size of a hole to change a lot.

[0103] F to which the thickness of the first pass increases and the inside of it is conveyed - If the effectual mobility of ion goes down F- in the tip of a hole ion concentration -- falling -- the formation of the holes -- an ion lack layer spreads in liquid -- formation -- Si is etched for the part to which the potential barrier of the interface of liquid and Si single crystal front face in a hole becomes low breadth and there, and the size of a hole may be increasing.

[0104] actually -- formation -- if a mobility limit layer does not exist in Si front face even if it enlarges a current simply - porosity -- not much -- not increasing -- rather -- formation -- a rate will increase. therefore, formation -- the case where it is going to change porosity a lot according to increase of a current -- a porosity increase layer and formation -- certain F- above, between liquid The mobility limit layer of ion is required. Then, if thickness of the above-mentioned porous layer first pass is made thickly around a base, the porosity of the second layer of the porous layer of the part can be made larger than the porosity whose thickness of the first pass of a center section is the second layer of a thin part, and it will become possible to weaken the mechanical strength of the isolation region of a base periphery by this.

[0105] This invention has the big description also in the point which can make the porosity of the layer 22 with said large porosity at a periphery larger than the center section of the base, when the mechanism of anodization is skillfully used for this appearance, and forming said isolation region which consists of a field of the shape of two or more layer where said mechanical strengths differ and said porosity makes thickness of the small layer 23 at a periphery larger than the center section of the base.

[0106] And a porous layer can be formed in a wafer by the anodization approach using simple equipment as shown in drawing 4 as mentioned above. In this way, it is possible to make thickness of the base periphery of a layer with small porosity thicker than a base center section, and to make larger than the porosity of a base center section the porosity of the base periphery of a layer with the big porosity which this forms after that. When distribution of such an inrush current needs to be further controlled to a precision, the current guide which controls the ion current distribution which flows into a base front face near the base to degas can be prepared, and distribution of the thickness of a layer with said small porosity can be controlled by controlling ion current distribution.

[0107] Moreover, it is as having shown and explained the water jet fuel injection equipment for separating a wafer and a

thin film semiconductor from the compound member of the first base and the second base to above-mentioned drawing 7.

[0108] Next, drawing 8 is drawing for explaining in detail an example of the structure of the lamination base which can be used for the approach of this invention, as mentioned above. In this example, the isolation region 3 has from this the two-layer structure with high porosity which mechanical strength becomes from 22 the second layer of weak porosity with the porosity first pass 23 with low porosity, as shown in drawing 8. In this invention, the second layer of the above-mentioned porosity, 22 makes porosity near the periphery of a base higher than a center section, or should just thicken the thickness. A crack produces separation in the inside of 22, or its interface the second layer of the porosity in a different location from a lamination interface. The second layer of porosity, since the mechanical strength is weak, if the force is added in the direction which the first base 21 and second base 27 separate, only 22 will be destroyed the second layer of porosity and both will separate 22. In case the layer 4 which the porosity first pass 23 turns into from the nonvesicular single crystal Si at this time is formed, in order to suppress generating of a crystal defect, it is required for a layer 4 as a protective layer for destruction not to reach at a separation process. It is better for the yield to have 22 the second layer of porosity preferably, although it is also possible to dissociate without forming 22 the second layer of porosity if porosity is not made so high, of course.

[0109]

[Example] Next, each example explains the contents of this invention still more concretely.

[0110] In [example 1] this example, anodization was performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with the twice [ about ] of the area of this Si base, and this was used.

[0111] The anodization conditions are as follows.

[0112] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

thus, the thickness of the center section of the porous layer of the degassed base -- the porosity of a center section was [ the porosity of the thickness of the porous layer of a periphery ] 30% in about 19 microns at the maximum about 20% at about 12 microns. Although created on such conditions, electron microscope observation can investigate the magnitude of the hole of a periphery, and it is [ part / deep / center section ] clearly large from a front face. However, near the front face of a porous layer, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si with few defects to the shape of a porous layer at a next process.

[0113] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. It was washed by fluoric acid, and after performing 950-degree C heat treatment in a hydrogen ambient atmosphere subsequently, 0.3 micrometers grew the single crystal Si epitaxially with the CVD method of the following conditions on Porosity Si.

[0114] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: -- 1x10<sup>-2</sup>Torr growth rate: -- it formed 100nm SiO<sub>2</sub> two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0115] This SiO<sub>2</sub> Superposition and after making it contact, heat treatment for 5 minutes was carried out for the layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination was performed. It set in the equipment which showed the compound member to drawing 7, when water jet injection was performed on water pressure 1000 kgf/cm<sup>2</sup> and conditions with a diameter of 0.15mm, the porosity Si layer fractured, the wafer was halved good and Porosity Si expressed [ two Si substrates ] it to the separation side. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. Selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It was changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si.

[0116] In this way, the obtained SiO<sub>2</sub> substrate was heat-treated in the hydrogen ambient atmosphere.

[0117] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result is obtained even if it does not form an oxide film in an epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and in order to obtain one more SOI substrate, it used it as 1st Si single crystal substrate again.

[0118] In [example 2] this example, anodization is performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with the twice [ about ] of the

area of this Si base, and this was used.

[0119] The anodization conditions are as follows.

[0120] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

Thus, in the thickness of the center section of the porous layer first pass of the degassed base, the porosity of a center section became about 20% by about 12 microns. The porosity of the thickness of the porous layer of a periphery was 30% in about 19 microns at the maximum. then, the first pass -- formation -- the second-layer formation is succeedingly performed on condition that the following the back.

[0121] Current density: 8 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 2 (minute)

When the second-layer formation was performed on the above conditions after first pass formation, the thickness of the center of the second layer became about 2 microns, and porosity became about 40%. However, in the periphery of a base, porosity is a maximum of about 55%, and the thickness is less than 2 microns.

[0122] However, near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si with few defects to the shape of a porous layer at a next process.

[0123] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. Next, HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3 micrometers grows a single crystal Si epitaxially with a CVD method on Porosity Si. The growth conditions were as follows.

[0124] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: -- 1x10<sup>-2</sup>Torr growth rate: -- it formed 100nm SiO<sub>2</sub> two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0125] This SiO<sub>2</sub> Superposition and after making it contact, heat treatment for - 5 minutes is carried out for a layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination is performed. In this way, the typical sectional view of the obtained compound member is shown in drawing 11 . As for the compound member, according to drawing 11 , 22 shows the condition of consisting a layer of the central part 33 and its circumference part 34 of 22 the central parts 35 and the circumference parts 36 of nothing and the porosity first pass 23, and the second layer of porosity, between the first base 1 and the second base 2, respectively an oxide film 6, the single crystal Si layer 4, the porosity first pass 23, and the second layer of porosity.

[0126] When the wafer end face was made to express a porous layer, Porosity Si was etched to some extent and the sharp plate was inserted there like the cutting edge of a razor by this drawing 11 , the porosity Si layer fractured, the wafer was halved and Porosity Si expressed it. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. Selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It was changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si. In this way, the obtained SOI substrate was heat-treated in the hydrogen ambient atmosphere.

[0127] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0128] In [example 3] this example, anodization was performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with the twice [ about ] of the area of this Si base, and this was used.

[0129] The anodization conditions are as follows.

[0130] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

thus, the thickness of the center section of the porous layer first pass of the degassed base -- the porosity of a center section was [ the porosity of the thickness of the porous layer of a periphery ] 30% in about 19 microns at the maximum about 20% at about 12 microns. the first pass -- formation -- the second-layer formation was succeedingly performed on condition that the following the back.

[0131] Current density: 8 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 2 (minute)

When the second-layer formation was performed on the above conditions after first pass formation, the thickness of the



center of the second layer was about 2 microns, and porosity was about 40%. However, in the periphery of a base, porosity was a maximum of about 55%, and the thickness was less than 2 microns.

[0132] However, near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si with few defects to the shape of a porous layer at a next process.

[0133] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3 micrometers grows a single crystal Si epitaxially with a CVD method on Porosity Si. The growth conditions are as follows.

[0134] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: --  $1 \times 10^{-2}$  Torr growth rate: -- it formed 100nm SiO<sub>2</sub> two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0135] This SiO<sub>2</sub> Superposition and after making it contact, heat treatment for 5 minutes is carried out for a layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination is performed. In this way, a compound member like drawing 11 mentioned above was obtained. When water jet injection is carried out to a wafer side face on water pressure 300 kgf/cm<sup>2</sup> and conditions with a diameter of 0.1mm, a porosity Si layer fractures, a wafer is halved very good and Porosity Si expresses it. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. Selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It was changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si. In this way, the obtained SOI substrate was heat-treated in the hydrogen ambient atmosphere.

[0136] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0137] In [example 4] this example, anodization was performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm, or N type into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with about 1.3 times of the area of this Si base, and this was used.

[0138] The anodization conditions are as follows.

[0139] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub> O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

Thus, the porosity of a center section of the thickness of the center section of the porous layer first pass of the degassed base was about 20% in about 6 microns. The porosity of the thickness of the porous layer of a periphery was 25% in about 8 microns at the maximum. the first pass -- formation -- the second-layer formation is succeedingly performed on condition that the following the back.

[0140] Current density: 12 (A)

anodization solution: -- HF:H<sub>2</sub> O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 1 (minute)

Near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si which does not have a defect on a porous layer at a next process.

[0141] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3-micrometer epitaxial growth of the single crystal Si was carried out with the CVD method on Porosity Si. The growth conditions are as follows.

[0142] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: --  $1 \times 10^{-2}$  Torr growth rate: -- it formed 100nm SiO<sub>2</sub> two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0143] Superposition and after making it contact, heat treatment for 5 minutes was carried out for this SiO<sub>2</sub> two-layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination was performed. If water jet injection is performed on water pressure 300 kgf/cm<sup>2</sup> and conditions with a diameter of 0.1mm there, without making a wafer end face express a porous layer, and etching Porosity Si to some extent, a porosity Si layer fractures, a wafer will be halved very good and Porosity Si will express it. Then, selective etching of the porosity Si layer was carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. By time amount shorter than an example 3, selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction

which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It is changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si. In this way, the obtained SOI substrate was heat-treated in the hydrogen ambient atmosphere.

[0144] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0145] In [example 5] this example, anodization is performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with about 1.3 times of the area of this Si base, and this was used.

[0146] The anodization conditions are as follows.

[0147] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

Thus, for the thickness of the center section of the porous layer first pass of the degassed base, the porosity of a center section was [ about 8 microns and the porosity of the thickness of the porous layer of a periphery ] 25% at the maximum about 20% in about 6 microns. the first pass -- formation -- the second-layer formation was succeedingly performed on condition that the following the back.

[0148] Current density: 12 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 1 (minute)

Near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si with few defects on a porous layer at a next process.

[0149] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3-micrometer epitaxial growth of the single crystal Si was carried out with the CVD method on Porosity Si. The growth conditions were as follows.

[0150] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: -- 1x10<sup>-2</sup>Torr growth rate: -- it formed 100nm SiO two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0151] Superposition and after making it contact, heat treatment for 5 minutes is carried out for this SiO two-layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination is performed. A wafer end face is made to express a porous layer, and Porosity Si is etched to some extent. in this way, it created -- many -- when the lamination base of several sheets was sunk into the tank of coincidence supersonic-wave irradiation equipment and the about 50kHz supersonic wave was irradiated, the porosity Si layer of all lamination bases broke, the wafer was halved at once and Porosity Si expressed it. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. By time amount shorter than an example 3, selective etching of the porosity Si is carried out, and it is removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It is changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si.

[0152] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0153] In [example 6] this example, the oxide film (SiO<sub>2</sub> layer) of 200nm(s) was formed in the 1st single crystal Si substrate front face by thermal oxidation as an insulating layer.

[0154] The first ion implantation was performed from the 1st substrate front face so that projection range might come into Si substrate here. Of this, the layer which works as an isolation region was formed in the place of the depth of projection range as a distortion layer by the very small air-bubbles layer or the impregnation ion kind high concentration layer. The ion implantation was again performed in the range of 10mm of peripheries of a substrate on the almost same conditions as the first time after this. Thereby, the ion injection rate of a periphery became twice [ about ] a center section.

[0155] After the above-mentioned ion implantation and this SiO<sub>2</sub> The layer front face and the front face of 2nd Si substrate prepared independently were heat-treated at the temperature of 600 degrees C, after making it contact, superposition and, and lamination was performed.

[0156] Holding in a core the lamination substrate formed as mentioned above, and rotating it around a medial axis, when

water jet injection was performed on water pressure 300 kgf/cm<sup>2</sup> and conditions with a diameter of 0.1mm in parallel with a lamination side from the periphery, said isolation region broke and the wafer was separated very good.

[0157] Consequently, SiO<sub>2</sub> formed in the first base front face from the first The remaining part of a detached core remained in the 1st substrate front face on which a part of layer, surface single crystal layer, and detached core were transferred to the 2nd substrate side. The 2nd substrate of the account of Gokami of the above-mentioned separation was annealed at 1000 degrees C, CMP equipment ground and removed the detached core transferred on the 2nd substrate after that, and the front face was graduated.

[0158] That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film can be formed. In this way, when the thickness of the single crystal Si layer formed on the done insulating layer was measured about the whole surface within a field in the 100-point location, the homogeneity of thickness was 201nm\*\*7nm.

[0159] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained.

[0160] When it furthermore heat-treated at 1100 degrees C in hydrogen for 1 hour and the atomic force microscope estimated surface roughness, the 2nd [ an average of ] power granularity in the field of 50-micrometer angle was equivalent to Si wafer usually marketed by about 0.2nm.

[0161] The same result is obtained, whether it forms an oxide film in the 2nd substrate front face instead of an epitaxial layer front face or forms in the both.

[0162] Moreover, the detached core which remained in the 1st substrate side can be reproduced by etching and surface polish, surface treatment, such as hydrogen annealing, can be performed further if needed, and it can supply as the 2nd substrate as the 1st substrate again.

[0163] Although this example is an example which relocates the surface field of Si wafer to the 2nd base through the detached core by the ion implantation from the first, it may transfer an epitaxial layer to the 2nd substrate through the detached core by the ion implantation using an epitaxial wafer. Moreover, it is a front face SiO<sub>2</sub> after the ion implantation of this example. After removing, an epitaxial layer is formed, and it is SiO<sub>2</sub> further. It may form, may go into a lamination process the back, and an epitaxial layer may be transferred to the 2nd substrate through the detached core by the ion implantation. As for the case of the latter, the surface field of Si wafer will also be relocated from the first.

[0164]

[Effect of the Invention] When according to each above-mentioned example separating a compound member and separation advances inside from the edge section of a lamination base even if it makes the force for separation high, both both [ one of the two or ] which were separated to the middle break.

[0165] Moreover, it can prevent that the particle which an isolation region collapses and generates pollutes a process. Moreover, the yield of separation can be improved also when it is going to dissociate by other approaches without using a fluid.

[0166] Furthermore, when separating a base from the isolation region made by the compound member of the stuck semiconductor base and others, at an intermediate process, separation does not take place but the compound member suitable for dissociating certainly can be formed in a separation process.

---

[Translation done.]

**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**TECHNICAL FIELD**

---

[Field of the Invention] Especially this invention relates to the manufacture approach of a semi-conductor base at the separation approach list which separates the compound member a compound mechanical strength has the weak brittle structured division inside about the manufacture approach of a semi-conductor base in a compound member and its separation approach list, and it. Especially this invention is suitable for the process of the substrate (SOI substrate) which has the SOI (Semiconductor on insulator) structure which is a kind of a semi-conductor base.

---

[Translation done.]

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

## PRIOR ART

---

[Description of the Prior Art] The device which adopted this SOI substrate has many dominance points which cannot be attained in the usual Si substrate. As this dominance point, the following are mentioned, for example.

- (1) Dielectric separation is easy and suitable for high integration.
- (2) Excel in radiation resistance.
- (3) Stray capacity is small and improvement in the speed of the working speed of a component is possible.
- (4) A well process is unnecessary.
- (5) A latch rise can be prevented.
- (6) Formation of the perfect depletion mold field-effect transistor by thin-film-izing is possible.

[0003] Since SOI structure has above various dominance points, research on the formation approach has been advanced for here dozens years.

[0004] as a SOI technique -- old -- a single crystal silicon-on-sapphire top -- Si -- CVD (chemistry gaseous layer growth) -- the SOS (silicon on sapphire) technique which is made to carry out hetero epitaxy growth and is formed by law is known. Although this SOS technique obtained evaluation temporary as a SOI technique which matured most, utilization is not progressing for the reasons of generating of a lot of crystal defects by the grid mismatching in the interface of Si layer and the silicon on sapphire of a substrate, mixing to Si layer of the aluminum which constitutes silicon on sapphire, the price of a substrate, the delay to large-area-izing, etc.

[0005] Subsequently to an SOS technique, the SIMOX (separation by ion implanted oxygen) technique appeared. Aiming at reduction of a crystal defect, reduction of a manufacturing cost, etc., various approaches have been tried about this SIMOX technique. On both sides of the approach and oxide film which pour in and embed oxygen ion as this approach at a substrate, and form an oxidizing zone, stick two wafers, and the wafer of 1 in all side is ground or etched. the approach of leaving a thin single crystal Si layer on an oxide film -- further After driving a hydrogen ion into the predetermined depth from the front face of Si substrate in which the oxide film was formed and sticking with the substrate of another side, it leaves a thin single crystal Si layer on this oxide film by heat-treatment etc., and the approach of exfoliating the stuck substrate (substrate of another side) etc. is mentioned.

[0006] A new SOI technique was indicated in the patent No. 2608351 official report or U.S. Pat. No. 5,371,037. This technique transfers a nonvesicular single crystal layer to the second substrate by removing a garbage for the first substrate in which the nonvesicular single crystal layer was formed on the single crystal semiconductor substrate with which the porous layer was formed, lamination and after that to the second substrate. This technique is excellent in respect of the ability to manufacture [ that the thickness homogeneity of a SOI layer is excellent, that the crystal defect consistency of a SOI layer can be reduced, that the surface surface smoothness of a SOI layer is good, that the manufacturing installation of an expensive special specification is unnecessary, ] the SOI substrate which has the SOI film of the range which is several 10nm - about 10 micrometers by the same manufacturing installation.

[0007] Furthermore, these people dissociated from the second substrate, without destroying the first substrate in JP,7-302889,A, after sticking the first above-mentioned substrate and second above-mentioned substrate, after that, are making the front face of the first separated substrate smooth, and forming a porous layer again, and indicated the technique which reuses the first substrate. One example of the approach indicated by the official report concerned is explained using drawing 12 (a) - drawing 12 (c). After porosity-izing the surface layer of the 1st Si substrate 1001 and forming a porous layer 1002, the single crystal Si layer 1003 is formed on it, and the principal plane of 2nd Si substrate 1004 with another this single crystal Si layer and first Si base is stuck through an insulating layer 1005 ( drawing 12 (a)). Then, a SOI substrate is formed by dividing the wafer stuck by the porous layer ( drawing 12 (b)), and removing alternatively the porosity Si layer exposed to the front face by the side of 2nd Si base ( drawing 12 (c)). The first Si substrate 1001 can remove and reuse the porous layer 1002 which remained.

[0008] Invention indicated by JP,7-302889,A is very useful when attaining low cost-ization of a semi-conductor substrate, since the substrate with which the structure of a porosity silicon layer dissociates and used the substrate for the production process of a semi-conductor substrate once using the brittle point compared with nonvesicular silicon can be

again used for the production process of a semi-conductor substrate. Moreover, since the first substrate can be used for this technique without futility, it can reduce a manufacturing cost sharply and has the outstanding advantage that a production process is also simple.

[0009] As an approach of separating the first base (substrate) of the above, and the second base (substrate) Others [ approaches /, such as pressurization, hauling shear, wedge insertion, heat treatment, oxidation, wave-motion impression, and a wire cut, ], There is an approach which this invention persons spray the fluid proposed in the application number 047 or No. 327 for which it applied to the U.S. on an isolation region, and separate on Japanese Patent Application No. No. 75498 [ nine to ] and March 25, 1998. As this fluid, a gas and/or a liquid are used and the water jet using the liquid which uses especially water as a principal component etc. can use it preferably. On the occasion of separation, this approach enters equally the clearance between not only an operation but the first base and the second base with which water cuts a lamination side, and can put a comparatively uniform separation pressure on the whole separation side. Moreover, this approach cannot sprinkle particle like [ in the case of a gas ], but can flush it rather. The approach of separating by wedge insertion is excelled in these two points. When especially the mechanical strength of an isolation region is made brittler than a lamination part, by spraying the flow of a fluid on this, only a brittle part is fractured, destroyed or removed and the part with the other strong reinforcement has the big advantage that it can leave without being destroyed.

---

[Translation done.]

**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**EFFECT OF THE INVENTION**

---

[Effect of the Invention] When according to each above-mentioned example separating a compound member and separation advances inside from the edge section of a lamination base even if it makes the force for separation high, both both [ one of the two or ] which were separated to the middle break.

[0165] Moreover, it can prevent that the particle which an isolation region collapses and generates pollutes a process. Moreover, the yield of separation can be improved also when it is going to dissociate by other approaches without using a fluid.

[0166] Furthermore, when separating a base from the isolation region made by the compound member of the stuck semiconductor base and others, at an intermediate process, separation does not take place but the compound member suitable for dissociating certainly can be formed in a separation process.

---

[Translation done.]

**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**TECHNICAL PROBLEM**

---

[Problem(s) to be Solved by the Invention] However, if the reinforcement of an isolation region is strong when it is going to separate the stuck compound member using fluids, such as a water jet, and a fluid is sprayed a side face, especially near an isolation region side face a compound member, flow of a fluid may be unable to destroy or cut an isolation region easily. In such a case, although it can dissociate by heightening the pressure of a fluid, if a pressure is made high too much, as the crack advances inside from the side face of a lamination base, it may be divided for the pressure of the fluid with which both both [ one of the two or ] which were separated were poured into the isolation region. For this reason, the yield fall might occur in the separation process. Although one approach for avoiding this is weakening the mechanical strengths of all isolation regions further, and making it brittler structure, when it weakens too much, an isolation region breaks during the handling of the base of the heating process and washing process in the middle of a compound member creation process, and others, it may not result in lamination, or an isolation region may collapse, particle may occur and it may become a pollution source.

[0011] Moreover, since the same problem arises fundamentally also when it is going to dissociate by other approaches without using a fluid, the yield in a separation process may fall.

[0012] The purpose of this invention is to offer the compound member which can separate a compound member comparatively easily, and its separation approach, without damaging the separated base.

[0013] Another purpose of this invention is to offer the compound member which the mechanical strength of an isolation region could be strengthened comparatively, suppressed collapse which an isolation region does not mean, and suppressed generating of particle, and its separation approach.

---

[Translation done.]



**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**MEANS**

---

[Means for Solving the Problem] This invention can be attained by the manufacture approach of the semi-conductor base characterized by the uneven thing in the separation approach of a compound member including the process which divides a compound member into two or more members in an isolation region in the direction in which the mechanical strength of an isolation region met the front face of a compound member.

[0015] It is desirable that the mechanical strength of the compound member periphery of said isolation regions is especially weaker than a center section. Moreover, as for said isolation region, it is desirable to coincidence that a mechanical strength is weaker than said lamination part.

[0016] This isolation region can use the layer which can obtain the very small air bubbles formed of the porous layer formed by the anodization method, or ion implantation. When using semi-conductor bases, quartz wafers, etc., such as Si wafer, as the first base of the above, or the second base, although these have the orientation flat and the notch, since it is disc-like in general, said compound member which sticks these first bases and the second base of each other, and changes is also outline discoid. In such a case, the mechanical strength of said isolation region has the high heterogeneity to which it becomes low by the periphery in the core in this compound member, and the in general more uniform one is divided into a circumferencial direction good. When a compound member is rectangular plate-like part material, the mechanical strength of the corner, one side, or the perimeter is weakened.

[0017] A mechanical strength can be made into an ununiformity by forming in said isolation region the part from which porosity differs mutually. Since a mechanical strength becomes weak so that porosity is enlarged, a mechanical strength is changed by changing porosity. The mechanical strength in the periphery can be weakened by more specifically making porosity higher than a center section at a periphery.

[0018] Said isolation region can make a mechanical strength an ununiformity also by changing the thickness. Since a mechanical strength becomes weak, a mechanical strength also changes by changing the thickness, so that thickness of said isolation region is thickened. Therefore, the porous layer of said isolation region can weaken the mechanical strength in the periphery also by making the thickness at a periphery larger than the center section of the base.

[0019] In order to obtain the compound member which was more suitable although separation does not take place at the process before the separation process of said compound member but it dissociates certainly at a separation process, it is more desirable to form said isolation region from two or more layers from which a mechanical strength differs. It is desirable that the porosity which adjoins a nonvesicular single crystal half conductor layer makes thickness of a layer with high porosity thinner than the thickness of a low layer into said isolation region which consists of two or more above-mentioned layers especially. There is not necessarily no need that the structure of each layer in it changes steeply in the interface, as for two or more above-mentioned layers. Though it is changing continuously by the interface of adjacent layers, it becomes easy to separate the reinforcement and structure of each class rather than reinforcement is uniform over the whole isolation region.

[0020] In said isolation region which consists of two or more layers from which said mechanical strength differs, it is more desirable that the porosity of a layer with said high porosity is more higher than near the center section of the base at a periphery.

[0021] When forming said isolation region which consists of a field of the shape of two or more layer where said mechanical strengths differ, the porosity which is the 2nd layer with said large porosity can be made at a periphery larger than the center section of the base by making at a periphery thickness which is the 1st layer with said small porosity larger than the center section of the base.

[0022] this invention persons were conducting the experiment which performs various reconstruction to anode plate degassing equipment that a good porous layer should be formed. It found out then that there was an Si wafer which has the field internal division cloth of porosity in two or more Si wafers which performed porosity-ized processing using the anode plate degassing equipment of a certain gestalt.

[0023] Moreover, it turned out that the sample in which the nonvesicular layer was formed on the porous layer is prepared, and there is a sample which can exfoliate more easily from what has comparatively high porosity even if the

porosity of a porous layer is comparatively low, when the experiment which exfoliates the nonvesicular layer is conducted.

[0024] If it sets to the porous layer to which porosity has field internal division cloth like the operation gestalt mentioned later based on the two above-mentioned knowledge and the layer of the degree of Kota hole fractures or collapses comparatively, the layer of comparatively low porosity will also be fractured easily and it will not receive effect in the absolute value of porosity so much.

[0025] That is, when there is a layer of the degree of Kota hole relatively [ periphery / which is easy to make separation start / of a member ], irrespective of the absolute value of the porosity, it finds out that separation becomes easy and came to make this invention.

[0026]

[Embodiment of the Invention] Drawing 1 (a) - drawing 1 (c) are the sectional views of the compound member by the gestalt of 1 operation of this invention.

[0027] As a compound member is shown in drawing 1 (a), the first base 1 and second base 2 stick mutually, are set, and are formed, and the isolation region 3 is formed in the interior. Here, the first base 1 has a lamination interface in the place which is contacted on the front face of the second base 2, is stuck, and shows the layer 4 formed on the isolation region 3 to a sign 5.

[0028] The mechanical strength has the comparatively strong part 31 and the weak part 32, and an isolation region 3 has the part 32 with a weak mechanical strength in the periphery (periphery of an isolation region) of a compound member.

[0029] Since the weak part 32 of a mechanical strength exists in the periphery of a compound member relatively when separating this compound member, a crack or collapse arises into this part 32 previously, and it becomes easy to separate a compound member.

[0030] For explaining in more detail, drawing 1 (a) formed the part 32 which consists of a porous body with high porosity in the periphery of the isolation region 3 where thickness is uniform, and has formed the weak part 32 of a mechanical strength locally at the periphery by forming the part 31 which consists of a porous body with low porosity in the center section. Drawing 2 (a) shows the location of the strong part 31 of the mechanical strength at the time of seeing this compound member from a top face, and the weak part 32. A sign 7 is an orientation flat prepared if needed.

[0031] Moreover, the weak part 32 of a mechanical strength may be a part of periphery section, as shown in drawing 2 B instead of all the peripheries of a compound member. It is desirable to make area of the strong part 31 of a mechanical strength sufficiently larger than the area of the weak part 32.

[0032] Drawing 1 (b) is making into an ununiformity thickness of the isolation region 3 which consists of a porous body of uniform porosity, and forms the weak part 32 of a mechanical strength in a periphery. As the flat surface of an isolation region 3 is shown in drawing 2 B also in this case, it may be locally formed in a part of periphery section.

[0033] Drawing 1 (c) forms the weak part 32 of a mechanical strength by forming a part with many ion injection rates in a periphery by ion implantation. Also in this case, as shown in drawing 2 (b), an ion injection rate can be locally made [ many ] and the weak part 32 of a mechanical strength can also be formed in a part of periphery section. Since very small air bubbles will arise if a hydrogen ion and rare gas ion are driven in and predetermined heat treatment is performed, the part by which the ion implantation was carried out to high concentration can also be made into a porous body with high porosity.

[0034] Both, the weak part 32 of a mechanical strength is higher than other parts, is thickening and may form the porosity and thickness of a porous body locally. Moreover, ion may be locally driven into the isolation region which consists of a porous body, the porous body of the part by which the ion implantation was carried out may be made brittle, and a mechanical strength may be weakened.

[0035] That is, it is also desirable to combine suitably the description part of a configuration of to have been shown in drawing 1 (a) - drawing 1 (c).

[0036] As the first base 1 used for this invention, tabular semi-conductor wafers other than Si wafer, such as germanium, SiGe, SiC, GaAs, GaAlAs, and InP, GaN, are used preferably.

[0037] As the second base 2, you may be insulating bases, such as quartz glass and a resin sheet, and metallicity bases, such as stainless steel, besides the same semi-conductor wafer as the first base 1.

[0038] The monolayer or two or more layers which consist of an ingredient chosen from the same semiconductor material as the ingredient of the first base as a nonvesicular layer are used preferably. When separating composite material and producing a SOI substrate, it is desirable that it is a single crystal half conductor layer.

[0039] What was formed with different ingredients from a layer 4, such as an insulator or a conductor, as a layer 6 shown in drawing 1 (c) is used preferably.

[0040] And when sticking the first and the second base, it is desirable to also make an insulating layer and the layer of adhesives intervene in between.

[0041] Drawing 3 (a) and drawing 3 (b) are graphs which show relatively distribution of the mechanical strength within the field of a compound member.

[0042] The part from a certain location LE 2 which a mechanical strength increases a continuous line 107 from the left periphery edge LE 1 of a compound member gradually toward the right periphery edge RE1 of a compound member to the center O toward Center O, and includes Center O to a location RE2 is the gestalt which a mechanical strength is the strongest and is fixed.

[0043] An alternate long and short dash line 108 is a gestalt in which the mechanical strength has changed intermittently between the periphery section (part from [ from the periphery edge LE 1 to a location LE 2 ] the periphery edge RE1 to a location RE2), and a center section (from a location LE 2 to a location RE2).

[0044] A broken line 109 is a gestalt which the mechanical strength is increasing from the periphery edges LE1 and RE1 continuously towards Center O, and, as for a mechanical strength, takes maximum in the Center O.

[0045] In this invention, it is desirable that the mechanical strength in the part from the location of the method of the inside of 5mm to the periphery edge of an isolation region weakens locally rather than the mechanical strength in a center section toward a center from the periphery edge of a compound member. If it is made to correspond to drawing 3 (a), it is desirable to form an isolation region as a film so that the location of the method of the inside of 5mm may consist of a periphery edge of a compound member toward a center between LE1 and LE2 and/or between RE2 and RE1.

[0046] Furthermore, when separating the compound member of the diameter of macrostomia from the periphery edge toward the center, it may be unable to dissociate so that the center section of the compound member may wish. In this case, it is good to form the weak part of a mechanical strength in the center locally.

[0047] Drawing 3 (b) shows an example of such a gestalt, and the high part of a mechanical strength is the doughnut-like part M between a periphery and a center.

[0048] As an isolation region, when using a porous layer, it is good for a mechanical strength to make the porosity of a weak periphery 35% or more more preferably 20% or more, and to make the upper limit of porosity 80% or less. Although the porosity of the center section where a mechanical strength is strong should be just lower than a periphery, it is good to choose desirably, so that it may become it is more desirable and lower than 5% or more of less than 20% of within the limits to a periphery less than 35% 5% or more.

[0049] If there is 10% or more of differences of porosity more preferably 5% or more, the difference of sufficient mechanical strength to divide a compound member into a periphery and a center section easily will be acquired.

[0050] Moreover, what is necessary is just to make the porosity of the part in which this part M, i.e., a mechanical strength, has the maximal value in making an isolation region from a porous body, since it becomes a part with the part strong [ a mechanical strength ] which shows with Sign M in the case of drawing 3 (b) more preferably as low as less than 20% 5% or more less than 35% 5% or more as well as the center section of drawing 3 (a).

[0051] The porosity of the center O in drawing 3 (b) is good to choose from 20% - 80% of range suitably that what is necessary is just more highly than Part M, so that the relation may be filled.

[0052] Porosity [ of a porous body ] P (%) expresses the rate of the volume which a hole occupies in the volume of the appearance of a porous body here. This porosity is expressed with the following formula using the consistency m of a porous body and the consistency M of a nonvesicular object which were formed on said 1st base.

[0053]  
$$P = \{(M-m)/M\} \times 100 \text{ (1)}$$

Here, weight G of the appearance of the porous-layer object containing a hole is \*(ed) by the volume V of the appearance of the porous body containing a hole with the consistency m of a porous body.  $m = G/V$  (2)

It comes out. In order to ask for the porosity P of the porous layer of the base which actually has layer structure only whose depth d by the side of a front face is a porous body, it can ask from a degree type using the weight B of the base after removing completely the weight a and the porous layer of said base after forming the weight A and the porous layer of a base before forming a porous layer.

[0054]  
$$P = \{(A-a)/(A-B)\} \times 100 \text{ (3)}$$

Next, the production approach of a compound member is described.

[0055] First, the first base 1 like Si wafer is prepared, and an isolation region 3 is formed in the part of the predetermined depth from the front face or a front face. There is the approach of forming in the part of the predetermined depth the ion implantation layer from which impregnation ion concentration serves as max from the front face of the first base 1 by carrying out the ion implantation of the different ion from the configuration element of a base like the approach and/or hydrogen ion which porosity-ize the front face of the first base 1 by anodization etc., or rare gas ion as a method of forming an isolation region. By controlling the conditions of anodization, and the conditions of ion implantation by the below-mentioned procedure, the weak part of a mechanical strength is made to a periphery.

[0056] Next, the nonvesicular layer 4 is formed on an isolation region 3 if needed, and it sticks on the 2nd base. In using ion implantation, the surface of the first base turns into the nonvesicular layer 4 as it is. In using porosity-ization, it forms a layer 4 by sputtering or CVD on the front face of the first porosity-ized base 1.

[0057] And the nonvesicular layer 4 is stuck on the 2nd base like Si wafer through an insulating layer 6 direct or if needed. In this way, a compound member is done.

[0058] One approach with being such for forming the weak porous layer of a mechanical strength locally is changing the current density of anodization in a field. the formation which flows into the periphery of a semi-conductor base -- by making current density high in the periphery of a base, it is thicker than the center section of the base, and the thickness and/or the porosity in a periphery of a base of said porous layer can be made high. In order to realize the above current density distribution, it is making the cross section to which the ion current in anodization liquid [ / near the base degassed ] flows in the case of anodization larger than the area of the base to degas. the formation which flows into a base periphery by this -- the formation which flows the surface density of a current in the center of a base -- what is necessary is just to make it larger than the surface density of a current What is necessary is to enlarge and for a base just to receive the ion current of the cross section larger than the area of a base from the base which degases specifically used  
\*\*\*\*\*

[0059] Drawing 4 shows notionally the equipment used for anodization. As for the DC power supply for anodization in 101, and 102, in drawing 4 , a cathode electrode and 103 are anode electrodes. 104,105 is an insulating supporter holding the processed base 1, and carries out the engagement of the base 1 in a crevice. 106 is an insulating layer pars basilaris oissis occipitalis.

[0060] here -- the area of an electrode 102,103 -- 1.2 time [ of the area of a base 1 ] - they are 1.3 times to about 2.0 times more preferably 3.0 times.

[0061] If it is made this appearance, in case the ion which has flowed from an outside [ edge / of a base / periphery ] will be brought together in a base, it flows in mostly by the periphery of a base, and it is large in the thickness of the porous layer of that part, and porosity can be made high.

[0062] Furthermore, it is possible to perform two or more steps of anodization, to make thickness of the periphery of the 1st porous layer thicker than a center section, and to make higher than the porosity of a center section the porosity of the periphery of the 2nd porous layer which this forms after that.

[0063] When distribution of such an inrush current needs to be further controlled to a precision, the current guide which controls the ion current distribution which flows into a base front face near the base to degas can be prepared, and distribution of the thickness of a layer with said small porosity can be controlled by controlling ion current distribution.

[0064] In using the layer which can obtain the very small air bubbles (microcavity) formed of said ion implantation as said isolation region, by making the consistency of ion implantation high, the magnitude and the consistency of the above-mentioned very small air bubbles, thickness over which very small air bubbles are distributed can be enlarged, and, thereby, it can make the mechanical strength of this field small.

[0065] Then, it is possible by making the ion injection rate of a base periphery larger than a base center section to raise the very small air-bubbles consistency per unit volume of a base periphery, and to make porosity higher than a base center section.

[0066] Drawing 5 is a graph which shows the field internal division cloth about the diameter direction of the porosity of the porosity acquired by the approach as shown in drawing 4 .

[0067] Since a mechanical strength becomes weak so that porosity becomes high, compared with the continuous line 107 of drawing 3 (a), the continuous line 207 and dotted line 209 of this drawing 5 are the pattern of vertical reverse from this graph.

[0068] If the ratio of the area of an electrode 102,103 to the area of a base is large enough, it will become like a continuous line 207, and when the ratio of the area of an electrode to the area of a base is small, there is an inclination which becomes like a broken line 209. In this way, the porous body of the degree of Kota hole can be formed in a periphery.

[0069] The technique of on the other hand making the porous layer of mechanical-strength distribution as shown in the alternate long and short dash line 11 of drawing 1 (a) and drawing 3 (a) is described. The 1st approach is as follows. The photoresist pattern used as the mask of an ion notes necessity is prepared only in the periphery section of a base 1, and boron ion is injected into a center section. Anodization using the electrode of the almost same area is given with a base to the base with which the boron ion concentration of the periphery section became low locally, and the periphery section makes the porous layer of low porosity [ center section ] from the degree of Kota hole.

[0070] The 2nd approach is as follows. Except for the periphery section of a base, a center section is covered with anodization-proof masks, such as a wax, general anodization is performed under the conditions of high current density, and the periphery section is porosity-ized.

[0071] Next, the mask of the periphery section is carried out, general anodization is performed under the conditions of a low current consistency, and a center section is porosity-ized.

[0072] The 3rd approach also has the approach only the periphery section raises porosity by ion implantation, after forming a uniform porous layer by general anodization. If ion injection rate distribution is controlled, a porous layer with intensity distribution as shown in drawing 3 (a) and drawing 3 (b) can be formed with a sufficient controllability.

[0073] However, probably, in respect of a manufacturing cost, the approach shown in drawing 4 will be more advantageous than these approaches.

[0074] Next, the production approach of the compound member shown in drawing 1 (c) is described more concretely.

[0075] A base like Si wafer is oxidized and an insulator layer 6 is formed. The ion implantation of hydrogen or the rare gas ion is carried out to the whole base surface with predetermined acceleration voltage. The center section except the periphery section is covered with a photoresist mask pattern, and ion is driven in with the again same acceleration voltage as the periphery section. In this way, the isolation region 3 with the weak part 32 of a mechanical strength can be formed.

[0076] A mask pattern is removed and an insulator layer 6 is stuck on the second base 2. A mechanical strength should just set heteroatom concentration of a weak part to  $10^{20}\text{cm}^{-3}$ - $10^{23}\text{cm}^{-3}$ , using a dose [ in / for the dose in the 1st ion implantation / the 2nd ion implantation ] as  $10^{15}\text{cm}^{-2}$ - $10^{17}\text{cm}^{-2}$ , respectively.

[0077] Next, the separation approach of the compound member used for this invention is explained. As shown in drawing 6 (a), a compound member is divided into explaining the gestalt which separates the compound member shown in drawing 1 (a) as an example using the internal stress generated by heat treatment etc., and external force. Among isolation regions 3, since a periphery 32 has a locally weak mechanical strength, this collapses first or a crack produces it first here. Drawing 6 (a) shows signs that apply the force 111 which inserts a wedge 110 and pulls apart the periphery of the first base 1 from the second base 2, and it dissociates.

[0078] And a compound member is divided into two as shown in drawing 6 (b). When the residual layer 37 of the isolation region 3 which remains on the nonvesicular layer 4 is comparatively thick, polish and etching remove a residual layer. And it heat-treats in a hydrogen ambient atmosphere if needed (hydrogen annealing). In this way, the base 2 equipped with the layer 4 which has a smooth front face as shown in drawing 6 (c) is obtained.

[0079] In the case of the application of a solar battery etc., it is not necessary to remove a residual layer.

[0080] As the separation approach of said usable compound member, to this invention Pressurization, hauling which are indicated by JP,7-302889,A, Various approaches, such as shear, wedge insertion, heat treatment, wave-motion impression, and a wire cut, and said the first base and second base which were stuck which were proposed by Japanese Patent Application No. No. 75498 [ nine to ] by spraying a fluid near the side face of said isolation region The approach of dividing into two or more members in a different isolation region from a lamination interface is usable.

[0081] In order to dissociate in this invention, the flow of the fluid to be used is realizable by injecting the pressurized fluid from a thin nozzle. as the approach for making flow to inject into a high speed and a high-pressure narrow beam more -- "a water jet" -- a fluid jet process which is introduced to the 4th page per volume [ 1st ] No. etc. can be used. Fluid jet usable to this invention is 100 pressurized by high pressure pumping -  $3000\text{ kgf/cm}^2$ . By injecting a high-pressure liquid from a nozzle with the thin diameter of about 0.1-0.5mm, cutting (however, an abrasive material is added to water at the time of a hard ingredient) of the ceramics, a metal, concrete, resin, rubber, wood, etc., processing, removal of a surface paint film, washing on the front face of a member, etc. can be performed. In how to use the conventional water jet, it was the main effectiveness to remove some ingredients as mentioned above. That is, carrying out water jet cutting only in that for a principal piece, and removing \*\* and removal of a paint film, and washing on the front face of a member were removing an unnecessary part.

[0082] As the formation approach of the flow of the fluid of this invention, when using a water jet, it is possible by injecting a water jet on the side face of said isolation region to separate a compound member. In this case, said isolation region side face is first exposed on the side face of a lamination base, and a direct water jet is injected on there and the outskirts of it. Then, each base does not receive damage, but only the isolation region where mechanical strength is brittle is removed by the water jet, and the base of two sheets is separated. Moreover, said isolation region side face is not exposed beforehand by a certain reason, and even when the part is covered by film like an oxide film, after removing a wrap layer for an isolation region first by the water jet, it can dissociate by the water jet.

[0083] Moreover, although it is the effectiveness which was not used in the conventional water jet, by injecting jet to the crevice of the side face of a compound member, said isolation region where structure is brittle can be extended, it can destroy, and a lamination wafer can also be separated. In this case, it is possible to dissociate without giving a damage on the surface of separation, without using abrasives, even if the cutting waste of an isolation region is hardly generated and an isolation region cannot remove with the jet itself as a material.

[0084] Thus, this effectiveness can also be considered to be the effectiveness of a kind of same wedge as what was shown in drawing 6 (a) by the fluid instead of effectiveness, such as cutting and polish. Therefore, by a crevice's having this effectiveness in the side face of a lamination base, and injecting jet, when the force is applied in the direction which lengthens and removes an isolation region, effectiveness can be expected very much. It is more desirable for the configuration of the side face of a compound member to be not a convex type but a concave, if it is fully going to demonstrate this effectiveness.

[0085] Drawing 7 is the outline perspective view showing an example of the water jet equipment used for the manufacture approach of the semi-conductor base used for this invention. In drawing 7 , a sign 1 is the compound

member which carried out the lamination unification of the two Si wafers, and an isolation region 3 exists in the interior. 403,404 is the holder which adsorbs / fixes the compound member 1 by the vacuum chuck, and exists on the same revolving shaft mutually. Furthermore, a holder 404 can be rotated at the speed of arbitration by connecting with susceptor 409 through bearing 408, and the speed-control motor 410 linking directly and being connected in the rear. Moreover, the holder 403 was connected with susceptor 409 through bearing 411, and the force is applied in the direction YA in which a holder 403 separates from the compound member 1 by minding a compression spring 412 between susceptors 409 in the rear.

[0086] First, it sets so that the compound member 1 may be learned from a gage pin 413, and it is made to adsorb/hold at a holder 404. if a holder 404 is about the compound member 1 at a gage pin 413 -- \*\*\*\* -- it is things and compound member 1 center section can be held. Next, the compound member 1 learns it from bearing 411, and advances it leftward until it adsorbs / holds a holder 403. As for a holder 403, at this time, the force takes rightward by the compression spring 412. As for the appearance which a holder 403 does not separate from the compound member 1 by the force by the compression spring 412, the force in which a compression spring 412 returns, and the force in which a holder 403 attracts the compound member 1, balance is maintained at this time.

[0087] Next, it continues taking out during 1 scheduled time until it sends water into the water jet nozzle 402 from the water jet pump 414 and the water to spout is stabilized. If water is stabilized, the water (following water jet water) which opened the shutter 406 and blew off from the water jet nozzle 402 on the side face of the compound member 1 will be hit. At this time, the compound member 1 and a holder 403 are rotated by rotating a holder 404. In the side face of the compound member 1, water jet water is hitting near the core of the thickness, it extends the compound member 1 from the periphery section to two bodies toward a core, destroys a comparatively weak isolation region within the compound member 1, and, finally divides it into two bodies.

[0088] Like, after [ which was mentioned above at this time ] dissociating since the force is working rightward while water jet water is equally poured on the compound member 1 and a holder 403 holds the compound member 1, it is the device in which compound member 1 separated comrades do not slide.

[0089] Moreover, a liquid with the operation which does not use water but etches alternatively the isolation region of alkali and others, such as acids, such as organic solvents, such as alcohol, and fluoric acid, a nitric acid, or a potassium hydroxide, as a fluid to be used etc. is usable. Furthermore, gases, such as air, nitrogen gas, carbon dioxide gas, and rare gas, may be used as a fluid. Gas and the plasma which have an etching operation to an isolation region can also be used. As for the water to be used, for the separation approach of the compound member introduced into the production process of a semi-conductor base, it is desirable to use water with the high purity of the pure water from which an impurity metal, particle, etc. were removed as much as possible, ultrapure water, etc. Moreover, if it washes after separation even if it uses fluid jet other than pure water, since it is a perfect low-temperature process, an impurity and particle can also be removed enough.

[0090] When using the approach of spraying such a fluid, it is desirable to give the configuration where it cratered in a concave which produces the force of the direction which extends an isolation region in response to liquid flow near the isolation region of said compound member. When it is going to separate the compound member with which the base of two sheets sticks and it comes to unite it across an isolation region in an isolation region, such structure can be easily realized by beveling the edge of each base.

[0091] When applying separating power to the isolation region currently beforehand formed in the compound member the flow of a fluid like a water jet, or by using the various approaches of pressurization, hauling, shear, wedge insertion, heat treatment, wave-motion impression, a wire cut, and others and separating into two, separation advances by [ of an isolation region ] destroying a brittle part mechanically. Also when the flow of a fluid is injected near an isolation region, the flow of a fluid removes or destroys the isolation region where a mechanical strength is brittle. And since the other part which is not brittle remains without being destroyed an isolation region being removed fundamentally [ in the case of a fluid ], there is an advantage that it can dissociate without damaging the part used after separation as a result. However, in the case of [ neither of ] the approaches, an isolation region may be unable to be destroyed if the reinforcement of an isolation region is not weak enough. For example, an isolation region may be unable to be destroyed or removed by the flow of the fluid of a predetermined pressure.

[0092] In order to solve this, when the pressure of a fluid is heightened, it is destroyed to the other part but not only an isolation region, for example, in separation of a lamination base, the tabular first or the second base may break. If the pressure of a fluid is lowered in order to prevent this, the dilemma that separation is impossible will arise.

[0093] It is necessary to stuff a solid wedge into the isolation region of the part formed in the periphery of a near [ the front face of the isolation region formed into the compound member at the initial stage of separation (for example, a disc-like lamination base) ] by the separation approach of above most. Thus, it is necessary to advance separation from a front face in many cases. However, the part near a front face has the problem that the area which applies separating power is small while separation does not advance, and the area consistency of the force must be made high. Although this can apply separating power to the separated field, it is because separating power cannot be applied to the field which



has not been separated yet. In the phase in which separation advanced, since the area which can apply separating power increases and the surface density becomes low even if it makes it easy to enlarge separating power applied to a separation side, and to separate, it becomes easy to prevent breakage (crack etc.) of the base accompanying separation. [0094] It is generated [ un-arranging / that an isolation region is destroyed / , and ], before thickening thickness of a porous layer which raises the porosity of the porous layer of an isolation region, or reaching a separation process in the middle of the formation process of said compound member in the early stages of separation by increasing the amount of formation of very small air bubbles by increasing the amount of ion implantation etc. if reinforcement becomes weak too much, although what is necessary is just to weaken mechanical strength in order to make separation easy.

[0095] It became clear that this invention persons changed the mechanical strength of an isolation region in the direction parallel to a lamination side, and should just weaken the mechanical strength of the part near the lamination base front face of said isolation region, for example, a periphery, compared with a base center section especially in order to avoid such un-arranging as a result of wholeheartedly research.

[0096] In the phase where the area of the field separated by the initial stage of separation cannot enlarge separating power small, the mechanical strength of an isolation region is weakened and separation is made to advance by the small force. This is possible by making small the mechanical strength of the isolation region near the periphery of a base. In the center section of the base, the mechanical strength of an isolation region is made higher than a periphery, and peeling in the middle of a process is prevented.

[0097] In this way, since the area which separation put in the center section and was separated at this time is large even if it sets, even if it makes surface density of separating power small, the whole separating power becomes large and can advance separation. Such effectiveness has the most desirable approach of injecting the flow of the above-mentioned fluid to an isolation region, in order to prevent breakage of a base, applying separating power to homogeneity comparatively in the whole field separated although it is not based on the separation approach but is demonstrated.

[0098] In order to make large the condition range for being stabilized and performing separation and to ensure separation without breakage of a base, the structure where an isolation region 3 consists of the field (22 23) of the shape of two or more layer where mechanical strengths differ like drawing 8 is desirable. In such a case, making the mechanical strength in a periphery small compared with the center section of the base can be realized comparatively easily. the case where the isolation region has a laminated structure of the layer 23 (this is called the porous layer first pass for convenience.) with small porosity, and the large layer 22 (this is called for convenience the second layer of a porous layer.) -- the layer 23 with small porosity -- first -- an anodization method -- forming -- after an appropriate time -- formation -- what is necessary is to enlarge a current and just to form the layer 22 with large porosity by the anodization method similarly

[0099] As for the porosity of 22, according to the place which this invention persons studied wholeheartedly, it turned out that it was not decided only by the magnitude of a current and is dependent also on the thickness and the porosity of the above-mentioned porous layer first pass 23 the second layer of the above-mentioned porous layer. the above-mentioned porous layer second -- formation of layer 22 -- even if it sets up a current equally, when the thickness of the above-mentioned porous layer first pass 23 is thick or porosity is low, there is an inclination for the porosity of 22 to become high the second layer of the above-mentioned porous layer. for this reason -- if thickness of the above-mentioned porous layer first pass 23 is made thin, for example, for keeping the porosity of 22 high the second layer of the above-mentioned porous layer -- a porous layer second -- formation of layer 22 -- it is necessary to make a current higher It is drawing 9 which showed this relation.

[0100] if -- formation of the second layer of a porous layer -- if a current is kept constant, and the thickness of the porous layer first pass changes, the porosity of the second layer of a porous layer will be influenced. Drawing 10 showed this relation. According to drawing 10 , it is the related Fig. of the porosity (%) of the second layer to first pass thickness (micron), and after forming the porous layer first pass, it is clear to affect the porosity whose property of the porous layer first pass is the second layer of a porous layer rather than to be able to form the second layer of a porous layer independently of this. The detailed mechanism of such a phenomenon cannot be solved completely. however, it mentions later -- as -- formation of Porosity Si -- formation -- F- in liquid ion needs -- having -- \*\*\*\* -- the hole formation section at the tip of a hole -- F- if ion is consumed -- the hole from the front-face side of Porosity Si -- inside -- passing -- new F-Ion needs to be conveyed and it needs to be supplied at the tip of a hole.

[0101] such a hole -- inner F- It is thought that it depends for the electric field of ion or the effectual mobility of transportation by diffusion on the hole size of the first pass or the die length of a hole, i.e., the thickness of the first pass. That is, the porous layer first pass itself formed of anodization restricts transportation of ion required for porous layer formation of the point.

[0102] Therefore, F which needs the formed porous layer first pass for formation of the porous layer of the point - It works as an effectual mobility limit layer of ion transport. formation -- if a current is fixed, formation advances, without porosity seldom changing to considerable thickness. This is F at a fixed current. - Although the hole of a certain size decided by consumption of ion and balance of supply is formed, when a current is increased on the way, it is F by existence of a porous layer [ finishing / formation / already ]. - It thinks for consumption of ion and the balance of supply

to change and for the size of a hole to change a lot.

[0103] F to which the thickness of the first pass increases and the inside of it is conveyed - If the effectual mobility of ion goes down F- in the tip of a hole ion concentration -- falling -- the formation of the holes -- an ion lack layer spreads in liquid -- formation -- Si is etched for the part to which the potential barrier of the interface of liquid and Si single crystal front face in a hole becomes low breadth and there, and the size of a hole may be increasing.

[0104] actually -- formation -- if a mobility limit layer does not exist in Si front face even if it enlarges a current simply - - porosity -- not much -- not increasing -- rather -- formation -- a rate will increase. therefore, formation -- the case where it is going to change porosity a lot according to increase of a current -- a porosity increase layer and formation -- certain F- above, between liquid The mobility limit layer of ion is required. Then, if thickness of the above-mentioned porous layer first pass is made thickly around a base, the porosity of the second layer of the porous layer of the part can be made larger than the porosity whose thickness of the first pass of a center section is the second layer of a thin part, and it will become possible to weaken the mechanical strength of the isolation region of a base periphery by this.

[0105] This invention has the big description also in the point which can make the porosity of the layer 22 with said large porosity at a periphery larger than the center section of the base, when the mechanism of anodization is skillfully used for this appearance, and forming said isolation region which consists of a field of the shape of two or more layer where said mechanical strengths differ and said porosity makes thickness of the small layer 23 at a periphery larger than the center section of the base.

[0106] And a porous layer can be formed in a wafer by the anodization approach using simple equipment as shown in drawing 4 as mentioned above. In this way, it is possible to make thickness of the base periphery of a layer with small porosity thicker than a base center section, and to make larger than the porosity of a base center section the porosity of the base periphery of a layer with the big porosity which this forms after that. When distribution of such an inrush current needs to be further controlled to a precision, the current guide which controls the ion current distribution which flows into a base front face near the base to degas can be prepared, and distribution of the thickness of a layer with said small porosity can be controlled by controlling ion current distribution.

[0107] Moreover, it is as having shown and explained the water jet fuel injection equipment for separating a wafer and a thin film semiconductor from the compound member of the first base and the second base to above-mentioned drawing 7.

[0108] Next, drawing 8 is drawing for explaining in detail an example of the structure of the lamination base which can be used for the approach of this invention, as mentioned above. In this example, the isolation region 3 has from this the two-layer structure with high porosity which mechanical strength becomes from 22 the second layer of weak porosity with the porosity first pass 23 with low porosity, as shown in drawing 8. In this invention, the second layer of the above-mentioned porosity, 22 makes porosity near the periphery of a base higher than a center section, or should just thicken the thickness. A crack produces separation in the inside of 22, or its interface the second layer of the porosity in a different location from a lamination interface. The second layer of porosity, since the mechanical strength is weak, if the force is added in the direction which the first base 21 and second base 27 separate, only 22 will be destroyed the second layer of porosity and both will separate 22. In case the layer 4 which the porosity first pass 23 turns into from the nonvesicular single crystal Si at this time is formed, in order to suppress generating of a crystal defect, it is required for a layer 4 as a protective layer for destruction not to reach at a separation process. It is better for the yield to have 22 the second layer of porosity preferably, although it is also possible to dissociate without forming 22 the second layer of porosity if porosity is not made so high, of course.

---

[Translation done.]



\* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

EXAMPLE

---

[Example] Next, each example explains the contents of this invention still more concretely.

[0110] In [example 1] this example, anodization was performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with the twice [ about ] of the area of this Si base, and this was used.

[0111] The anodization conditions are as follows.

[0112] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

thus, the thickness of the center section of the porous layer of the degassed base -- the porosity of a center section was [ the porosity of the thickness of the porous layer of a periphery ] 30% in about 19 microns at the maximum about 20% at about 12 microns. Although created on such conditions, electron microscope observation can investigate the magnitude of the hole of a periphery, and it is [ part / deep / center section ] clearly large from a front face. However, near the front face of a porous layer, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si with few defects to the shape of a porous layer at a next process.

[0113] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. It washed by fluoric acid, and after performing 950-degree C heat treatment in a hydrogen ambient atmosphere subsequently, 0.3 micrometers grew the single crystal Si epitaxially with the CVD method of the following conditions on Porosity Si.

[0114] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: -- 1x10<sup>-2</sup>Torr growth rate: -- it formed 100nm SiO<sub>2</sub> two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0115] This SiO<sub>2</sub> Superposition and after making it contact, heat treatment for 5 minutes was carried out for the layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination was performed. It set in the equipment which showed the compound member to drawing 7, when water jet injection was performed on water pressure 1000 kgf/cm<sup>2</sup> and conditions with a diameter of 0.15mm, the porosity Si layer fractured, the wafer was halved good and Porosity Si expressed [ two Si substrates ] it to the separation side. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. Selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It was changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si.

[0116] In this way, the obtained SiO<sub>2</sub> substrate was heat-treated in the hydrogen ambient atmosphere.

[0117] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result is obtained even if it does not form an oxide film in an epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and in order to obtain one more SOI substrate, it used it as 1st Si single crystal substrate again.

[0118] In [example 2] this example, anodization is performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with the twice [ about ] of the area of this Si base, and this was used.

[0119] The anodization conditions are as follows.

[0120] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

Thus; in the thickness of the center section of the porous layer first pass of the degassed base, the porosity of a center section became about 20% by about 12 microns. The porosity of the thickness of the porous layer of a periphery was 30% in about 19 microns at the maximum. then, the first pass -- formation -- the second-layer formation is succeedingly performed on condition that the following the back.

[0121] Current density: 8 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 2 (minute)

When the second-layer formation was performed on the above conditions after first pass formation, the thickness of the center of the second layer became about 2 microns, and porosity became about 40%. However, in the periphery of a base, porosity is a maximum of about 55%, and the thickness is less than 2 microns.

[0122] However, near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si with few defects to the shape of a porous layer at a next process.

[0123] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. Next, HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3 micrometers grows a single crystal Si epitaxially with a CVD method on Porosity Si. The growth conditions were as follows.

[0124] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: --  $1 \times 10^{-2}$  Torr growth rate: -- it formed 100nm SiO<sub>2</sub> two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0125] This SiO<sub>2</sub> Superposition and after making it contact, heat treatment for - 5 minutes is carried out for a layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination is performed. In this way, the typical sectional view of the obtained compound member is shown in drawing 11 . As for the compound member, according to drawing 11 , 22 shows the condition of consisting a layer of the central part 33 and its circumference part 34 of 22 the central parts 35 and the circumference parts 36 of nothing and the porosity first pass 23, and the second layer of porosity, between the first base 1 and the second base 2, respectively an oxide film 6, the single crystal Si layer 4, the porosity first pass 23, and the second layer of porosity.

[0126] When the wafer end face was made to express a porous layer, Porosity Si was etched to some extent and the sharp plate was inserted there like the cutting edge of a razor by this drawing 11 , the porosity Si layer fractured, the wafer was halved and Porosity Si expressed it. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. Selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It was changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si. In this way, the obtained SOI substrate was heat-treated in the hydrogen ambient atmosphere.

[0127] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0128] In [example 3] this example, anodization was performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with the twice [ about ] of the area of this Si base, and this was used.

[0129] The anodization conditions are as follows.

[0130] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

thus, the thickness of the center section of the porous layer first pass of the degassed base -- the porosity of a center section was [ the porosity of the thickness of the porous layer of a periphery ] 30% in about 19 microns at the maximum about 20% at about 12 microns. the first pass -- formation -- the second-layer formation was succeedingly performed on condition that the following the back.

[0131] Current density: 8 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 2 (minute)

When the second-layer formation was performed on the above conditions after first pass formation, the thickness of the center of the second layer was about 2 microns, and porosity was about 40%. However, in the periphery of a base, porosity was a maximum of about 55%, and the thickness was less than 2 microns.

[0132] However, near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single

crystal of Si with few defects to the shape of a porous layer at a next process.

[0133] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3 micrometers grows a single crystal Si epitaxially with a CVD method on Porosity Si. The growth conditions are as follows.

[0134] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: --  $1 \times 10^{-2}$  Torr growth rate: -- it formed 100nm SiO two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0135] This SiO<sub>2</sub> Superposition and after making it contact, heat treatment for 5 minutes is carried out for a layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination is performed. In this way, a compound member like drawing 11 mentioned above was obtained. When water jet injection is carried out to a wafer side face on water pressure 300 kgf/cm<sup>2</sup> and conditions with a diameter of 0.1mm, a porosity Si layer fractures, a wafer is halved very good and Porosity Si expresses it. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. Selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It was changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si. In this way, the obtained SOI substrate was heat-treated in the hydrogen ambient atmosphere.

[0136] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0137] In [example 4] this example, anodization was performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm, or N type into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with about 1.3 times of the area of this Si base, and this was used.

[0138] The anodization conditions are as follows.

[0139] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

Thus, the porosity of a center section of the thickness of the center section of the porous layer first pass of the degassed base was about 20% in about 6 microns. The porosity of the thickness of the porous layer of a periphery was 25% in about 8 microns at the maximum. the first pass -- formation -- the second-layer formation is succeedingly performed on condition that the following the back.

[0140] Current density: 12 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 1 (minute)

Near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si which does not have a defect on a porous layer at a next process.

[0141] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3-micrometer epitaxial growth of the single crystal Si was carried out with the CVD method on Porosity Si. The growth conditions are as follows.

[0142] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: --  $1 \times 10^{-2}$  Torr growth rate: -- it formed 100nm SiO two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0143] Superposition and after making it contact, heat treatment for 5 minutes was carried out for this SiO two-layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination was performed. If water jet injection is performed on water pressure 300 kgf/cm<sup>2</sup> and conditions with a diameter of 0.1mm there, without making a wafer end face express a porous layer, and etching Porosity Si to some extent, a porosity Si layer fractures, a wafer will be halved very good and Porosity Si will express it. Then, selective etching of the porosity Si layer was carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. By time amount shorter than an example 3, selective etching of the porosity Si was carried out, and it was removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It is changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si. In this way, the obtained SOI substrate was heat-treated in the hydrogen ambient atmosphere.

[0144] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not

introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0145] In [example 5] this example, anodization is performed for the 1st single crystal (100) Si substrate of the diameter of 8 inch of the P type (or N type may be used) with the thickness of 625 micrometers of specific resistance 0.01 ohm-cm into HF solution. formation of anode plate-ized stratification -- \*\*\*\*\* was created so that the cross section of a field parallel to an electrode and the above-mentioned Si single crystal base might be changed with about 1.3 times of the area of this Si base, and this was used.

[0146] The anodization conditions are as follows.

[0147] formation -- current: -- 2.6 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 11 (minute)

Thus, for the thickness of the center section of the porous layer first pass of the degassed base, the porosity of a center section was [ about 8 microns and the porosity of the thickness of the porous layer of a periphery ] 25% at the maximum about 20% in about 6 microns. the first pass -- formation -- the second-layer formation was succeedingly performed on condition that the following the back.

[0148] Current density: 12 (A)

anodization solution: -- HF:H<sub>2</sub>O:C<sub>2</sub>H<sub>5</sub>OH=1:1:1 hour: -- 1 (minute)

Near the front face of the porous layer first pass, the difference with a center section or a periphery remarkable in the magnitude of a hole is not seen. This is very important when carrying out epitaxial growth of the single crystal of Si with few defects on a porous layer at a next process.

[0149] This substrate was oxidized at 400 degrees C among the oxygen ambient atmosphere for 1 hour. The wall of the hole of Porosity Si was covered with this oxidation by the thermal oxidation film. HF solution washes, and after heat-treating in a hydrogen ambient atmosphere, 0.3-micrometer epitaxial growth of the single crystal Si was carried out with the CVD method on Porosity Si. The growth conditions were as follows.

[0150] source gas: -- SiH<sub>4</sub> carrier gas: -- H<sub>2</sub> temperature: -- 900-degree-C pressure: -- 1x10<sup>-2</sup>Torr growth rate: -- it formed 100nm SiO<sub>2</sub> two-layer in this epitaxial Si layer front face by thermal oxidation further 3.3 nm/sec.

[0151] Superposition and after making it contact, heat treatment for 5 minutes is carried out for this SiO<sub>2</sub> two-layer front face and the front face of Si substrate prepared independently at 1180 degrees C, and lamination is performed. A wafer end face is made to express a porous layer, and Porosity Si is etched to some extent. in this way, it created -- many -- when the lamination base of several sheets was sunk into the tank of coincidence supersonic-wave irradiation equipment and the about 50kHz supersonic wave was irradiated, the porosity Si layer of all lamination bases broke, the wafer was halved at once and Porosity Si expressed it. Then, selective etching of the porosity Si layer is carried out with the etching reagent of HF/H<sub>2</sub>O<sub>2</sub> / C<sub>2</sub>H<sub>5</sub>OH system. By time amount shorter than an example 3, selective etching of the porosity Si is carried out, and it is removed completely. The etch rate to this etching reagent of a nonvesicular Si single crystal is very low, and the amount of etching in a nonvesicular layer is thickness reduction which can be disregarded practically. That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film has been formed. It is changeless in a single crystal Si layer in any way also by the selective etching of Porosity Si.

[0152] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained. The same result was obtained even if it did not form an oxide film in the epitaxial Si layer front face. 1st Si single crystal substrate removed the residual porosity Si, and used it as 1st Si single crystal substrate again.

[0153] In [example 6] this example, the oxide film (SiO<sub>2</sub> layer) of 200nm(s) was formed in the 1st single crystal Si substrate front face by thermal oxidation as an insulating layer.

[0154] The first ion implantation was performed from the 1st substrate front face so that projection range might come into Si substrate here. Of this, the layer which works as an isolation region was formed in the place of the depth of projection range as a distortion layer by the very small air-bubbles layer or the impregnation ion kind high concentration layer. The ion implantation was again performed in the range of 10mm of peripheries of a substrate on the almost same conditions as the first time after this. Thereby, the ion injection rate of a periphery became twice [ about ] a center section.

[0155] After the above-mentioned ion implantation and this SiO<sub>2</sub> The layer front face and the front face of 2nd Si substrate prepared independently were heat-treated at the temperature of 600 degrees C, after making it contact, superposition and, and lamination was performed.

[0156] Holding in a core the lamination substrate formed as mentioned above, and rotating it around a medial axis, when water jet injection was performed on water pressure 300 kgf/cm<sup>2</sup> and conditions with a diameter of 0.1mm in parallel with a lamination side from the periphery, said isolation region broke and the wafer was separated very good.

[0157] Consequently, SiO<sub>2</sub> formed in the first base front face from the first The remaining part of a detached core remained in the 1st substrate front face on which a part of layer, surface single crystal layer, and detached core were

transferred to the 2nd substrate side. The 2nd substrate of the account of Gokami of the above-mentioned separation was annealed at 1000 degrees C, CMP equipment ground and removed the detached core transferred on the 2nd substrate after that, and the front face was graduated.

[0158] That is, the single crystal Si layer which had the thickness of 0.2 micrometers on Si oxide film can be formed. In this way, when the thickness of the single crystal Si layer formed on the done insulating layer was measured about the whole surface within a field in the 100-point location, the homogeneity of thickness was  $201\text{nm} \pm 7\text{nm}$ .

[0159] As a result of the cross-section observation by the transmission electron microscope, a new crystal defect was not introduced into Si layer, but it was checked that good crystallinity is maintained.

[0160] When it furthermore heat-treated at 1100 degrees C in hydrogen for 1 hour and the atomic force microscope estimated surface roughness, the 2nd [ an average of ] power granularity in the field of 50-micrometer angle was equivalent to Si wafer usually marketed by about 0.2nm.

[0161] The same result is obtained, whether it forms an oxide film in the 2nd substrate front face instead of an epitaxial layer front face or forms in the both.

[0162] Moreover, the detached core which remained in the 1st substrate side can be reproduced by etching and surface polish, surface treatment, such as hydrogen annealing, can be performed further if needed, and it can supply as the 2nd substrate as the 1st substrate again.

[0163] Although this example is an example which relocates the surface field of Si wafer to the 2nd base through the detached core by the ion implantation from the first, it may transfer an epitaxial layer to the 2nd substrate through the detached core by the ion implantation using an epitaxial wafer. Moreover, it is a front face  $\text{SiO}_2$  after the ion implantation of this example. After removing, an epitaxial layer is formed, and it is  $\text{SiO}_2$  further. It may form, may go into a lamination process the back, and an epitaxial layer may be transferred to the 2nd substrate through the detached core by the ion implantation. As for the case of the latter, the surface field of Si wafer will also be relocated from the first.

---

[Translation done.]

**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**DESCRIPTION OF DRAWINGS**

---

**[Brief Description of the Drawings]**

**[Drawing 1]** It is the typical sectional view of the compound member by this invention.

**[Drawing 2]** It is the plan of the compound member by this invention.

**[Drawing 3]** The field internal division cloth of the mechanical strength of the compound member by this invention is shown.

**[Drawing 4]** It is the state diagram which applies the anodization method used for this invention.

**[Drawing 5]** It is the property Fig. of the porous body of the semi-conductor base by this invention.

**[Drawing 6]** It is drawing showing the separation approach of the compound member by this invention.

**[Drawing 7]** It is the conceptual diagram of water jet equipment.

**[Drawing 8]** It is the sectional view of the compound member by this invention.

**[Drawing 9]** porous thickness and formation -- it is the property Fig. of a current.

**[Drawing 10]** It is the property Fig. of the porosity of the second layer to the thickness of the first pass.

**[Drawing 11]** It is the sectional view of the compound member by one example of this invention.

**[Drawing 12]** It is drawing showing the production process of the conventional semi-conductor substrate.

**[Description of Notations]**

1 First Base

2 Second Base

3 Isolation Region

4 Single Crystal Si Layer

5 Lamination Interface

6 Oxide Film

11 Power Source

12 Cathode

13 Positive Electrode

14 15 Wafer electrode holder

16 Wafer

21 First Base

22 Second Layer of Porosity

23 Porosity First Pass

24 Single Crystal Si Layer

25 Lamination Interface

26 Oxide Film

27 Second Base

401 Semi-conductor Base

---

[Translation done.]

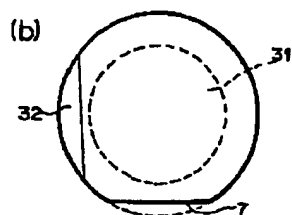
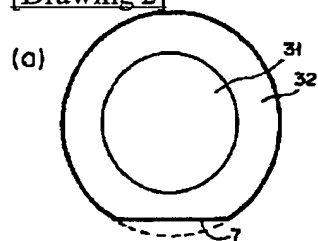
\* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

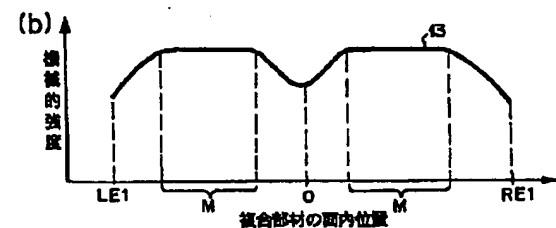
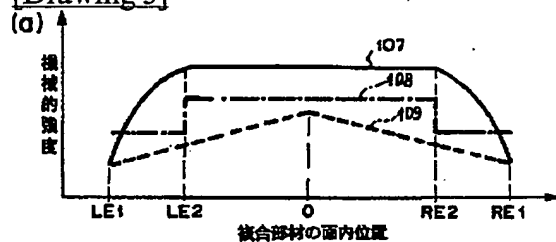
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DRAWINGS

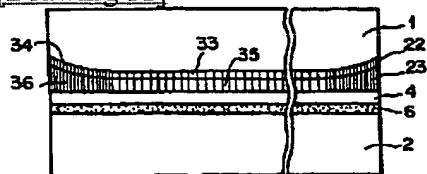
[Drawing 2]



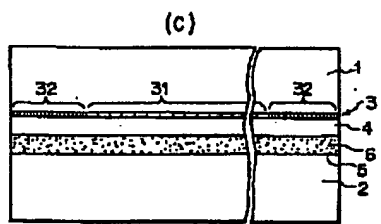
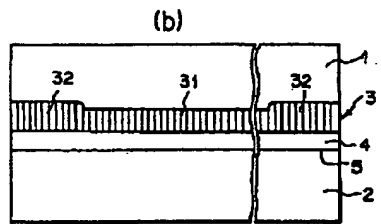
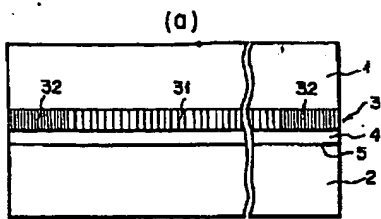
[Drawing 3]



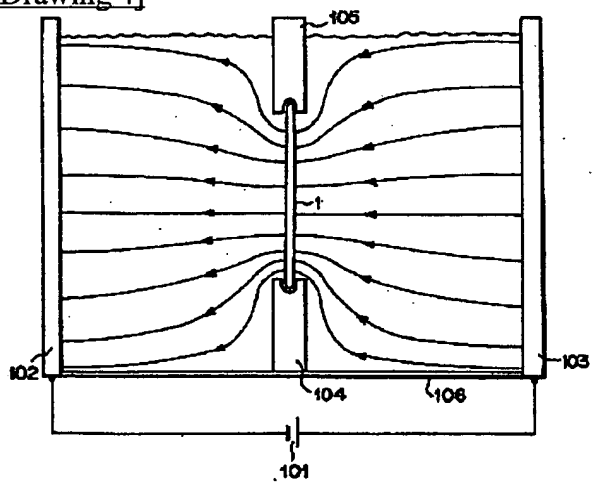
[Drawing 11]



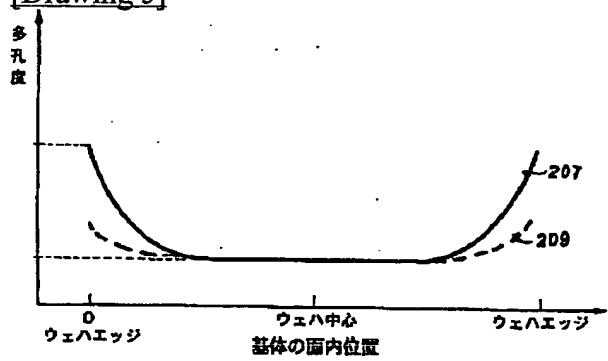
[Drawing 1]



[Drawing 4]



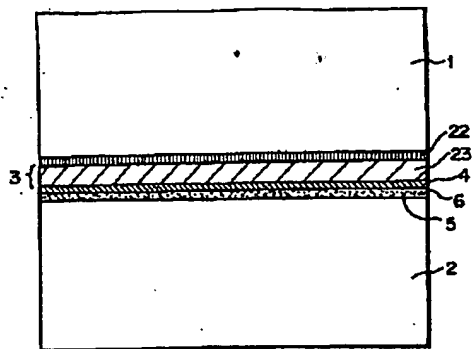
[Drawing 5]



[Drawing 6]

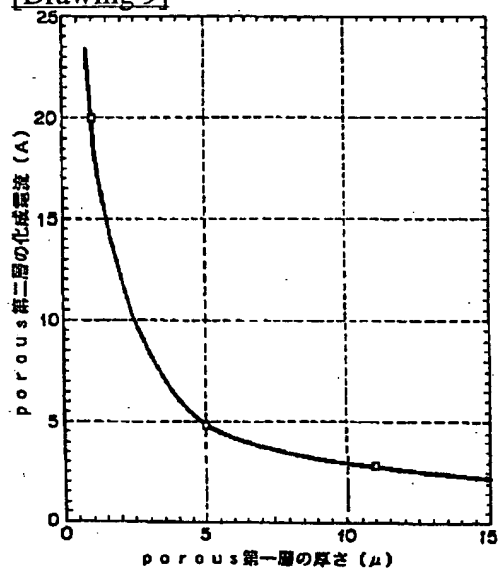




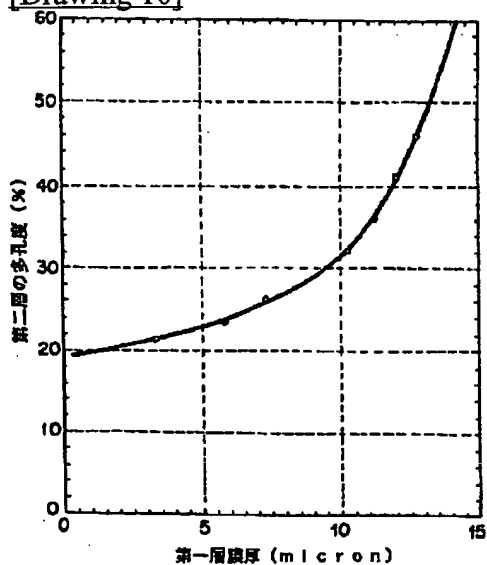


- 1: 第一の基体
- 2: 第二の基体
- 3: 分離領域
- 4: 厚結晶 Si 層
- 5: 貼り合わせ界面
- 6: 酸化膜
- 22: 多孔質第二層 (高多孔度)
- 23: 多孔質第一層 (低多孔度)

[Drawing 9]

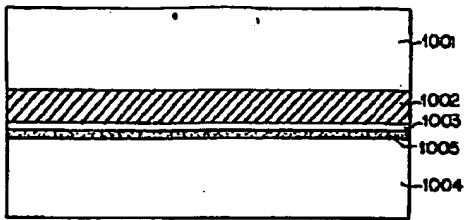


[Drawing 10]

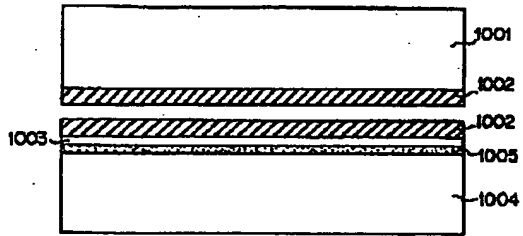


[Drawing 12]

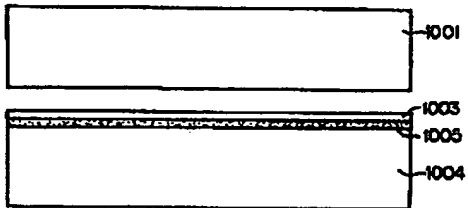
(a)



(b)



(c)



---

[Translation done.]

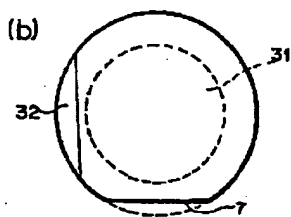
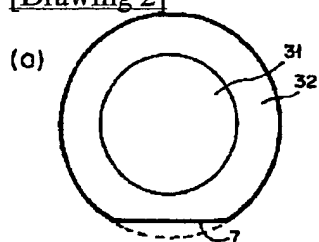
\* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

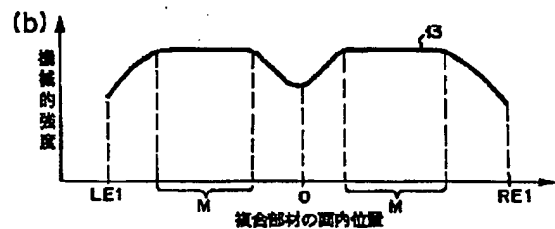
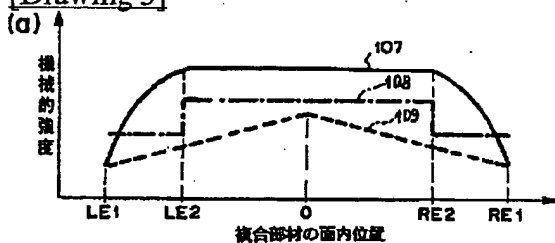
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DRAWINGS

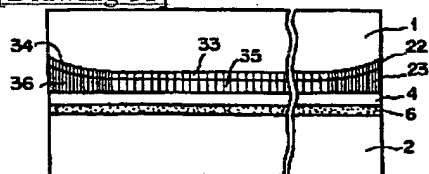
[Drawing 2]



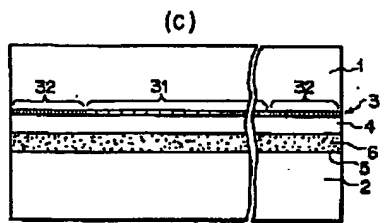
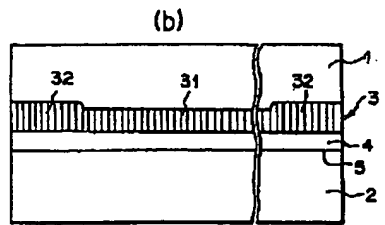
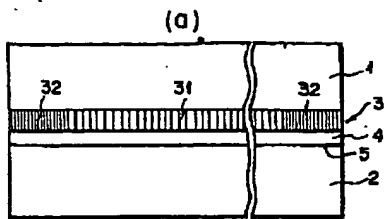
[Drawing 3]



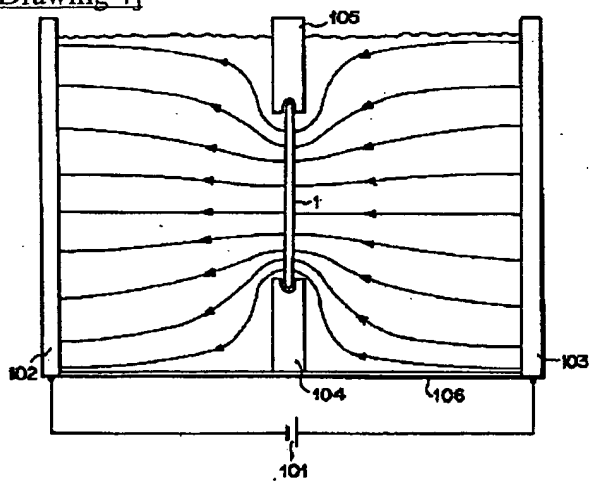
[Drawing 11]



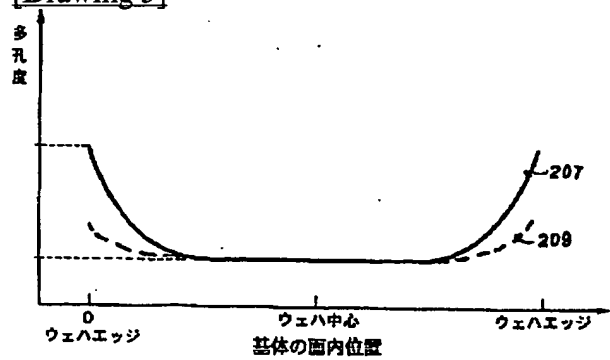
[Drawing 1]



[Drawing 4]

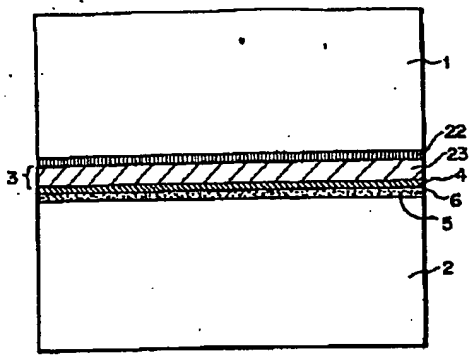


[Drawing 5]



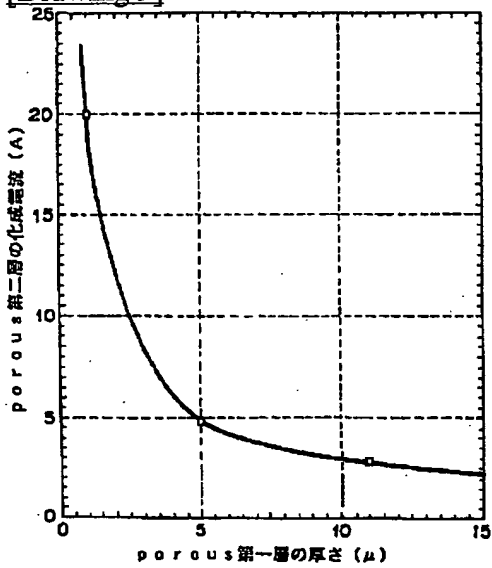
[Drawing 6]



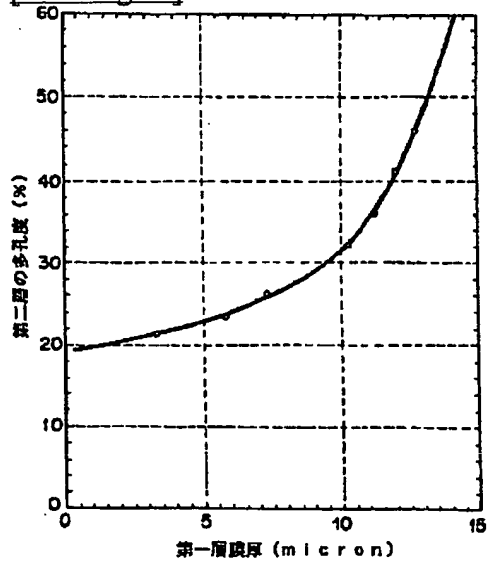


- 1 : 第一の基体
- 2 : 第二の基体
- 3 : 分離領域
- 4 : 単結晶 Si 層
- 5 : 貼り合わせ界面
- 6 : 酸化膜
- 22 : 多孔質第二層 (高多孔度)
- 23 : 多孔質第一層 (低多孔度)

[Drawing 9]

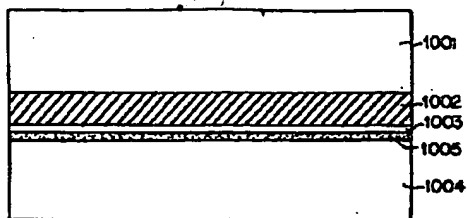


[Drawing 10]

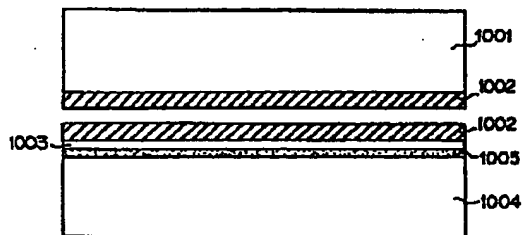


[Drawing 12]

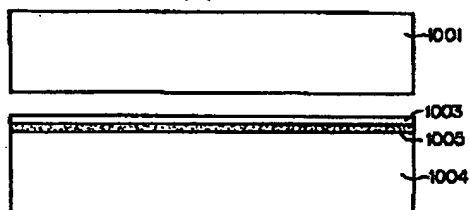
(a)



(b)



(c)



---

[Translation done.]



\* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

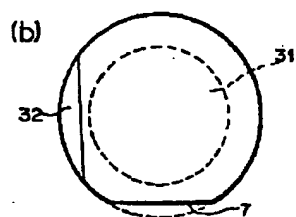
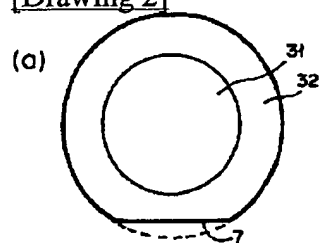
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

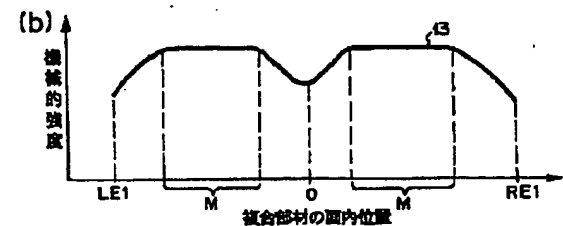
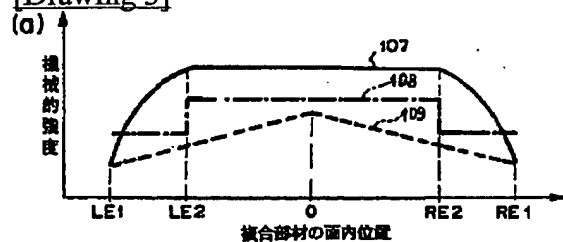
DRAWINGS

---

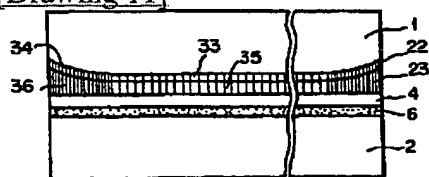
[Drawing 2]



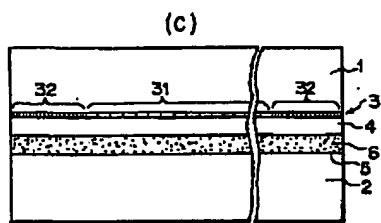
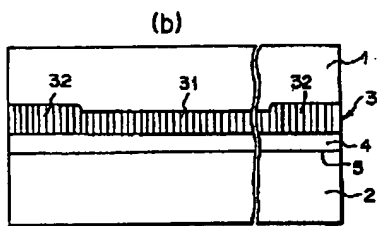
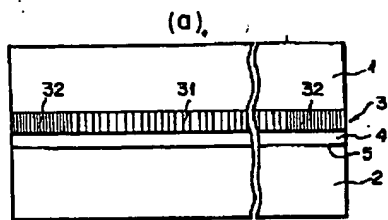
[Drawing 3]



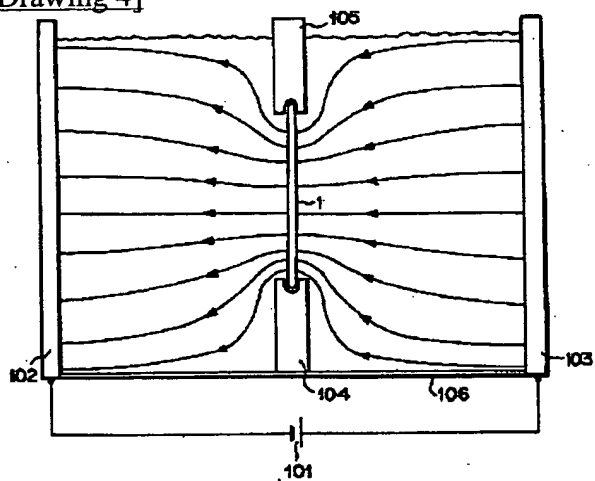
[Drawing 11]



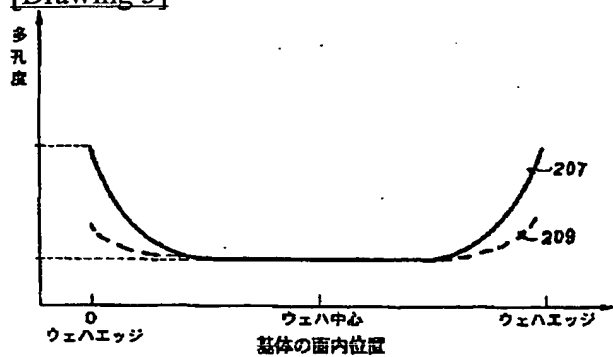
[Drawing 1]



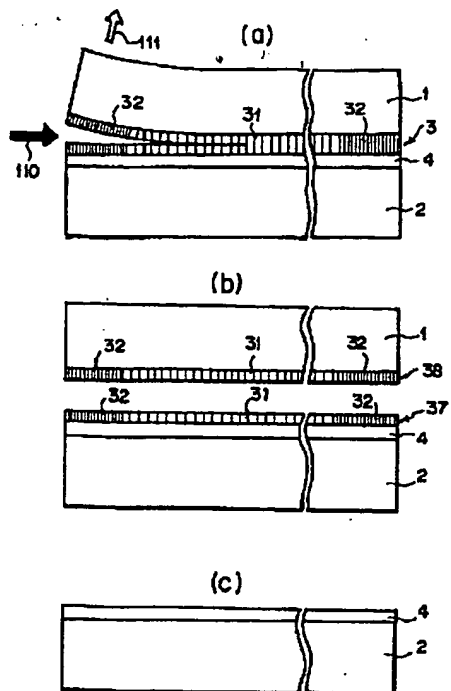
[Drawing 4]



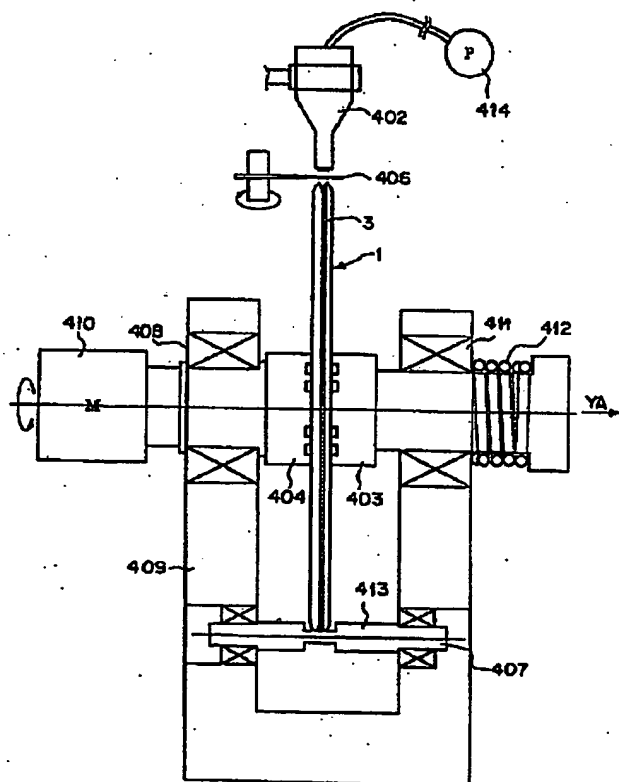
[Drawing 5]



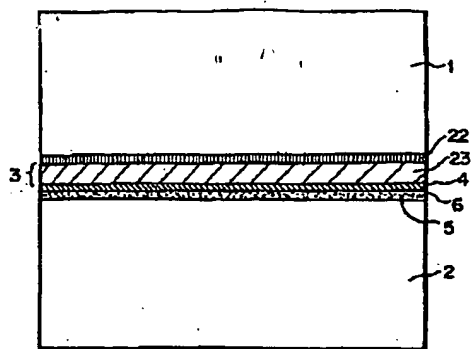
[Drawing 6]



[Drawing 7]

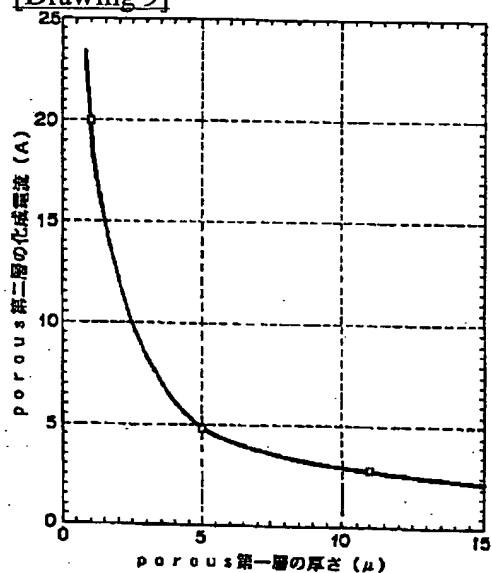


[Drawing 8]

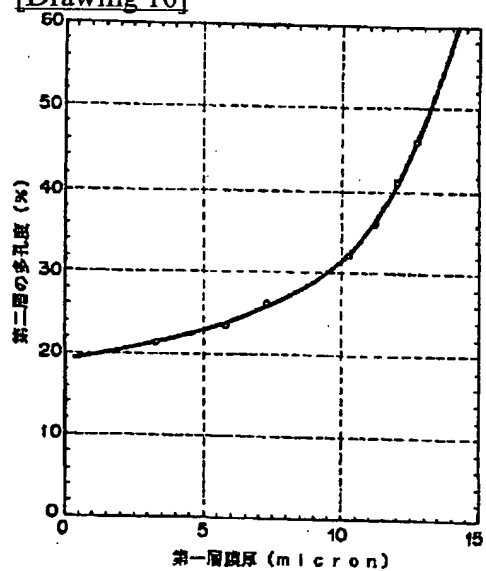


- 1 : 第一の基体
- 2 : 第二の基体
- 3 : 分離領域
- 4 : 単結晶 Si 層
- 5 : 貼り合わせ界面
- 6 : 酸化膜
- 22 : 多孔質第二層 (高多孔度)
- 23 : 多孔質第一層 (低多孔度)

[Drawing 9]

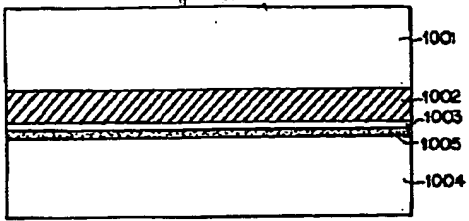


[Drawing 10]

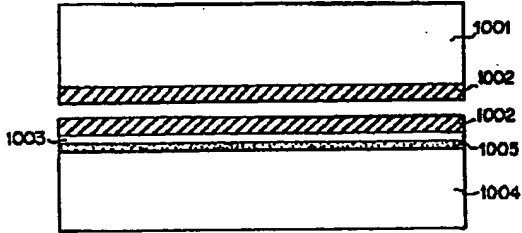


[Drawing 12]

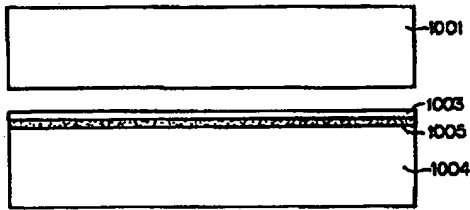
(a)



(b)



(c)



---

[Translation done.]

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**